Proposed Rating Index Algorithm/Procedure For Washington State Local Agencies

March, 2002

DRAFT

To: The NWPMA/WSDOT Committee on Pavement Index Score Review

From: Derald Christensen

Re: Proposed rating and index algorithm standard for local Washington State agencies

As discussed and agreed to in our January 8, 2002 Committee meeting, I am providing the attached Proposed Pavement Distress Index calculation procedure for use by Local Agencies in Washington State. The intent of this document is two fold; first it is intended as a formal history of past and current rating practices in Washington State and how and why they are used. The second is to provide a starting point for the Committee to help in making a final recommendation. Encompassed in both of these objectives is the fact that this document should also serve as a reference and as a learning tool to help each committee member to better understand our final goals. Therefore, some of the material provided in this document is provided for reference purposes only and is not intended for inclusion in any final document, which may be derived from what is included here.

The recommended distress rating procedures and associated score calculation algorithms provided here have been developed over several years (starting in 1984) and through the input of many different Washington State local agency personnel. Because of this, it obviously reflects the needs and desires of these individuals and their associated agencies. MRC has taken these procedures and refined them through many thousands of miles of ratings and applications to various agency PMS needs and objectives. In this process these rating procedures have been applied to both large and small agencies, both city and county agencies and to many different repair and maintenance strategy needs and has included driving, walking and video/laser surveys. This system is in use by over 30 Washington State local agencies, all of who do not wish to change their current rating method. Some of these agencies have over 15 years experience with these procedures.

Please do not take any errors or inconsistencies in this document for any reason other than the author's lack of time to edit it as thoroughly as he would wish or that things may have been included for completeness and form, even if the true facts need further research. It is in part the object of the intended review process to help with the final editing and to make any needed changes, additions or deletions to this document.

The current text contains many references to the committee and other general or informative discussion. These would obviously be removed from any final document, which may result from this proposal.

Respectfully,

Derald Christensen

Local Agency Pavement Distress Index Algorithm

Table of Contents

List of Figures

Proposed Rating Index Algorithm/Procedure For Washington State Local Agencies

Introduction

This document is intended as a proposed standard which can be used as a starting point for the NWPMA/WSDOT Rating Committee's consideration for a new rating score calculation procedure for use by Washington State Local City and County Agencies. The intent is for this procedure to augment the current NWPMA/WSDOT Pavement Surface Condition, Field Rating Manual, (currently in use by local agencies), by providing a flexible method for computing distress index values from the field rating data provide through the implementation of this document.

The basis for this proposed procedure was developed over the last 15 years through interaction between various Local Washington State Agencies and the WSDOT. It has been proven through many 1000's of miles of ratings by many different agencies. It's initial intent was to provide a detailed rating system which meets the specific needs of the local city and county agencies while still providing the data required to comply with the use of current and past WSDOT rating procedures and index score calculations.

This document starts out with a brief history of the various rating methods and related index score calculations which have been or are currently in use within the State, by both the local city and county agencies and the WSDOT. One of these methods which is currently in wide use, is then expanded on and is proposed as a starting point for the final recommendations which the above mentioned committee can work with and propose to the NWPMA/WSDOT as a final procedure which will be recommended for use by all local agencies.

Of key interest in the development of the procedures recommended here are the need to separate both structurally related and non-structurally related distresses to help better provide the information required for proper rehabilitation decisions as well as to address the level of detail required for using the results for routine and preventative maintenance operations. Also, careful attention has been given in the development of these procedures so as to provide data that can be used to comply with existing methods used by WSDOT and many of the counties. A final important aspect of the procedures being proposed here is the extreme level of flexibility in how they can be implemented.

Past experience has proven that if the rating procedures and the related score calculations are not flexible enough and to some extent definable by the user, that each agency tends to make changes which better meets their specific needs and the tendency is for multiple systems to develop. This recommended procedure has been implemented in such a way as to allow an agency to make modifications while still providing a means of standardizing on at least one index that can be maintained as a common standard that will provide a means of comparison between agencies. To meet this goal, a standard set of deduct curves needs to be developed and agreed on, while providing for a separate set of curves which the user can modify to meet specific goals.

The current NWPMA distress manual defines an “A” and “B” method, where the “A” method is intended for windshield type data collection and the “B” method is intended for more detailed distress surveys. The procedure proposed here and the way it is proposed to be implement provides for both of these methods. It also allows an agency to mix different aspects of each.

The final portion of this recommendation covers the proposed multiple indices and also contains a comparison of the index values produced by each of the methods discussed here along with the recommend use, advantages and limitations associated with each procedure.

History of Rating Methods in Use in Washington State

Introduction

The WSDOT was one of the first agencies to develop and implement a pavement distress rating system. They started developing their rating system and what they call a priority array in the 1960’s. The Washington State Legislature initially mandated the development of this procedure. This initial rating system included 4 distresses and a windshield method for collecting the data based on the predominant distress severity and % wheel path extent measurements.

There are four different rating systems currently in use in Washington State by the State and the Local Agencies all of which have been developed and/or condoned by the WSDOT. A fifth method (WSC2/OCI) which was developed by the local Washington agencies themselves through their NWPMS User’s Group, which was later reorganized into the current NWPMA organization. Also, there are two different WSDOT approved rating manuals and the original manual developed by the NWPMS group, which is the pavement distress description portion of the CenterLine PMS Raters Manual. The text from this manual is included in Appendix E.

The following is a list of rating methods currently being used:

1. Original WSDOT Matrix Base Windshield Rating method (PCR_1)
2. WSDOT Matrix Method modified for Local Agencies (PCR_2)
3. WSDOT Pavement Structural Condition Index (PSC_1) – continuous extents

3b. WSDOT Pavement Structural Condition Index (PSC_2) – discrete extent ranges

4. Streetwise Rating System (PCR_3)
5. WSDOT Local Agency Method Using ASTM Curves – Washington State City and County Rating Method (WSC2) or the modified ASTM method.

<u>1. Original WSDOT Matrix Base Windshield Rating Method (PCR_1)</u>

This method uses four distress types: Longitudinal cracking, alligator cracking, maintenance patching, and transverse cracks. Its basic premise is that it is a structural index, meant only to monitor load related fatigue (alligator) cracking. By definition, longitudinal cracking is the beginning stage of alligator cracking (low severity level), the alligator cracking distress type is defined as the intermediate or medium severity level and patching the advanced or high severity alligator cracking (it has gotten so bad as to require patching). The transverse cracks are included to help model the needs of Eastern Washington pavements, which are subjected to frost heave and related distress problems. To use this index correctly, the data must be collected as indicated by the above descriptions. Defining patching as the advanced stage of fatigue cracking and assigning high deduct values to it was done in part to ensure the continued deterioration (shape) of the performance curve model used by the WSDOT.

2. WSDOT Matrix Method adapted for Local Agencies (PCR_2)

In 1984 the WSDOT contracted with the University of Washington to develop a PMS for local agencies based on their current system. The above rating system (PCR_1) didn't meet the local agencies needs in several ways and thus was modified to address these differences.

First, other distress types were added and the deduct values modified in the deduct matrices. These new distress types included raveling, flushing, rutting, longitudinal reflective cracks, utility patching, block cracking, edge cracking, sags & humps and corrugations. Also, the definition for patching was modified to better meet the local agency needs.

3. WSDOT Pavement Structural Condition Index (PSC)

In 1993 the WSDOT and the University of Washington published the documentation for a new method of computing the index score for the States distress rating method (See WSDOT report WA-RD 274.1). No changes were made to the way the different distresses were rated, other than allowing for continuous extent measurements. This system uses a series of equations which were fit to existing data and developed around the idea of reducing each distress to its equivalent level of alligator cracking, a method similar in concept to the pavement design procedure which is based on equivalent thickness. This approach has some validity in the context of the above description of how the WSDOT rates their pavements, in that all they are actually monitoring is alligator (or fatigue) cracking. However, this method and this approach to computing the index does not apply to local agencies except possibly for high volume urban arterial pavements in the larger counties. But even to this day many of the counties do not rate their roads in complete compliance with the WSDOT procedures, even though most use the PSC index. The current WSDOT raters' manual does not even conform to the rating procedures required by the PSC and its initial development. This makes use of this index questionable by these local agencies. This index is not used by any of the local city agencies in Washington State nor is it used outside of this state.

The initial correlation work that was done by the DOT on these data with the PCR_1 data showed reasonable results. However, the DOT does not let their pavements go below a score of 50. This is not true for local agencies and the differences are reflected in the comparison shown later in Appendix D. This difference is quite severe for the higher extent of alligator cracking for all severity levels.

4. Streetwise System Distress Index (PCR_3)

This method uses five distresses: Alligator, longitudinal and transverse cracking, patching and raveling. That is, it adds raveling to the original WSDOT method. However, it differs in how the index value is computed. A series of index score based matrices are used and only two distresses are included; alligator cracking and the predominate one of the other distresses, if present. The purpose of this approach was to provide a simplified paper and pencil method for the smaller local agencies. From the comparisons shown in Appendix D, it is clear that no correlation work was done with any of the existing rating systems in developing the Streetwise matrix values. The future use of this index may be replaced by the index procedure resulting from the work of the current index evaluation committee.

5. Washington State City & County Rating Method (WSC2) or modified ASTM method

The original WSDOT matrix based system and the PSC if windshield data collection procedures are used, have a common shortcoming in that they were based on quantifying the extent using ranges or groupings and the predominate severity to help simplify their use for collecting data from a moving vehicle. This causes large variations in the results from year-to-year, and makes it extremely difficult to obtain consistent results from different raters. It also does not provide the data needed to manage maintenance operations. For these reasons (and others) the local agencies decided to go to a detailed quantification of each extent for each distress severity level by collecting and recording actual areas and lengths for each distress type and severity level. This method requires the use of continuous deduct curves in place of matrices. This method was developed from the PCR_2 procedure by the local agencies themselves and was adopted in the late 1980's. It is currently used by most local agencies involved in PMS in Washington State and is the primary method provided for in this proposed standard.

Unfortunately, deduct matrices or curves were never formally developed for the procedures adopted by the local agency or by the research project, which developed their PMS. Therefore, the individual agencies and software developers have adopted their own which has resulted in a large array of individual distress score index systems. The primary objective of this proposed document and of this committee is to establish these data and related procedures for computing distress indices.

Since most Washington Cities have adopted the WSC2 or OCI index method this has not been an extremely difficult problem for them. However, for the counties that wish to use distress data, which is not included in the PSC, they have been forced to adopt two indices, the PSC which is required by CRAB/WSDOT and the OCI, which provides the better index for making PMS related MR&R decisions. This can cause extreme difficulty in trying to share or communicate this type of data between various departments and/or individuals within an agency and to controlling bodies such as the CRAB and the WSDOT. Also, as can be seen in Appendix D, this can greatly effect the proper or optimized development of your MR&R lists.

A comparison of these indices is included in Appendix D. It can be seen that in the case of the PSC (WSDOT equations) and the PCR_3 (Streetwise), there is a relatively large difference in the deduct values assigned in many cases. For a single agency, using a single index score, this may or may not make any difference as long as the accompanying MR&R decision process matches the rating system/method and the desires of the user. However, make sure that your rating system can provide the trigger values and distress types you need to make the decisions required by your MR&R operations. It should also be noted that different indices can provide extremely different MR&R repair lists and care should be given to this fact when making decision as to how you rate your pavements and as to how you compute the related indices.

Some unique examples that relate to this topic include:

1. San Juan County, which has only rural chip seal roads; previously used the PSC to manage their system. Since most of their distress was flushing, they were not including their primary distress information in the score (PSC) values they were using to manage their pavements. Because CRIS included raveling and flushing on their data entry screen they assumed it was used in the calculation of the PSC and were unaware of the fact that it wasn't.
2. Arterial and Collector streets must be managed separately by most city agencies. Because of this a strictly structural based index may work for the arterial and collector arterial streets but would not be adequate for residential streets.
3. Most counties have separate urban and rural roadway networks, each of which requires different distress data to be manage properly. Only an index that includes structural and non-structural distress data can meet the combined needs of such a network.
4. Only a state route system that does not include local access or residential pavements can be managed from a structural index only.
5. Also, careful examination of the results in Appendix D applies.

Further Discussion

The original WSDOT PCR_1 & PSC rating procedures only include four distress types, Longitudinal Cracking, Alligator/Fatigue Cracking, Maintenance Patching and Transverse Cracking. Longitudinal Cracking is defined as the initial stage of load related Alligator Cracking. Alligator cracking is defined as fully developed Alligator Cracking and Patching as the advanced stage of Alligator Cracking (the repair of). Therefore, only two distress types are being monitoring, Alligator cracking and Transverse Cracking. For this reason the WSPSC & $WSPCR_1$ rating procedure and resulting computed scores represent a pavement structural index and are currently being called the PSC (Pavement Structural Condition Index). WSDOT originally called this the PCR or "Pavement Condition Index". Full details of how this system is implemented are included later in this document.

These rating systems are well suited for properly engineered pavements, which fail due to their designed repetitive truck loadings. However, it does not address or account for any other mechanism of pavement failure or provide an indicator of a pavements need for rehabilitation or maintenance due to distresses other then alligator cracking. This can be a limitation for local agencies and should be well understood when implementing and using these systems. The WSC2 rating system is designed for and intended as a natural expansion of these systems and provides full compatibility while providing for other needs, which are more indicative of local agency requirements. A comparable structural index can still be computed while allowing for other indices to be evaluated, such as environmentally (non-structural) related distresses, which includes raveling, as well as rutting, ride and roughness/profile.

The PCR_1 and PSC systems were intended to be used for statewide comparison purposes and must be implemented as outlined here to accomplish this. Therefore, a clear understanding of how these systems are used by WSDOT is important for local agencies to understand. The four distresses used in computing the PSC (and PCR_1) and the way in which the data is collected must be included in any system used by local agencies if these indices are to be computed. This will allow continued use of these systems and will allow continued use of previously collected data, while also providing for comparisons between agencies.

To address the need to compute different indices from the same data set and to try to provide continuity or comparable score results from one method to another, the WSC2 method includes several features. First, care was taken in defining the individual distresses and how the data is to be collected, so as to allow for the ability to meet the needs and requirements of each of the different rating and score calculation method. This is most apparent in the separation of longitudinal cracking into separate structural and non-structural distresses. The structural longitudinal cracks are then compatible with the PSC requirements while still allowing for the collection of data for the non-structural longitudinal cracks. Also, since utility repairs make up a large proportion of a local agencies patches, the separation of this distress type into utility and maintenance patching allows for compatibility with how the PSC handles patching, while also providing data that is more useable by the local agencies. This separation also helps address the many current issues associated with the better management of utility patches. These types of considerations allow both the CDI and PSC indices to be computed from the same data set if care is taken to following the proper distress definition and quantification procedures during data collection.

The WSC2 system being proposed here also provides user defined units of measure for each distress type, which can be changed from one survey year to the next. Examples of this would be the ability to switch from percent length or wheel path extent measurements to the quantification of the actual distress area measurements. Also, this proposed unit of measure conversion capability includes the ability to switch from discreet extent ranges (Method A) to detailed extent measures (Method B in the current NWPMA/WSDOT raters manual) within the same piece of software or to mix the two within the same index. This capability was originally developed to help local agencies to migrate from the original WSDOT $PCR_{1\&2}$ rating methods, to the WSC2 method and has been used and proven over the last 15 years. <u>By using this feature the proposed WSC2 method includes both the Method A and Method B definitions provided for in the current WSDOT raters manual in one system or process.</u>

If other changes should result from further development of this new standard, care needs to be taken to insure that previously collected data and previous procedures for computing indices is compatible and can be used in the development of fitted performance curves which are based on past and current distress scores/indices. Not adhering to this, along with any other possible changes to the existing system (WSC2) that do not meet an individual agencies needs will only result in them altering their procedures. That is, the more one tries to constrict and force an agency to comply with a standard that does meet their needs the higher the probability that an agency will be forced to modify how they implement their rating system and the more fragmented things become. This is evident in the fact that there are six different rating systems currently in use by local Washington State Agencies. Also, some of the larger agencies have modified their rating systems, in some cases quite extensively to meet their individual needs. This means that there are actually a lot more than the six rating systems discussed here currently in use within the State. <u>Only a properly designed and agreed to standard will result in a uniform rating system statewide</u>.

$WSPCR_1$ - Washington State Discrete Pavement Condition Rating System

Introduction

This system is based on the pavement distresses and rating procedures outlined as the "Core Distresses" in the original raters manual provided by WSDOT, and to some extent in the Method A of the current WSDOT local agency distress raters manual and is summarized here. It includes alligator, longitudinal and transverse cracking and patching and was used by the WSDOT for many years, until the early 1990's when they switched to the PSC method which is outlined later in this document.

Objective

This system was developed with the goal of optimizing its use for collecting the distress data from a moving vehicle. It is a structural pavement distress index, in that it only reflects structural type distresses caused by heavy repeated traffic loadings and the repair and maintenance of these distresses.

Method

The extents associated with all three severity levels of each distress are grouped, (summed), together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data as they drive the roadway. This method is also used by some agencies for walking surveys. The data being collected can be put directly into a form, or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value, (which is called a deduct value). These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number located at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems associated with these negative values. The ASTM rating system defines a tapering or smoothing process, which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the $WSPCR_{1\ \&\ 2}$ procedures and should be an available option within your PMS software and included with this proposed standard. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR_1 = 100 - \sum_i Deducts_i$$

Recommended Use

This method is still used by some Washington State Local Agencies and is ideal for low budget applications and network level budget planning. This method can be easily expanded by changing to an actual area and length method of measuring the extent and the recording of data for each severity level.

Figure 1 - Extent Ranges Used for each Distress Type

Extent Ranges	Alligator Cracking	Longitudinal Cracking	Transverse Cracking	Patching
1	0 - 9%	1% - 99%	1 - 4 Cracks	1% - 9%
2	10% - 24%	99% - 199%	5 - 9 Cracks	10% - 24%
3	25% - 49%	200% or more	10 or more	25% or more
4	50% or more	-	-	-

Figure 2 - Asphalt and Bituminous Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 3 - Composite Pavement Deduct Matrix

Extent	Alligator Cracks			Longitudinal Cracks			Transverse Cracks			Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	50	5	15	30	5	10	15	20	25	30
2	25	40	55	15	30	45	10	15	20	25	30	35
3	30	45	60	30	45	60	15	20	25	30	40	50
4	35	50	65	-	-	-	-	-	-	-	-	-

Figure 4 - Portland Cement Concrete Pavement Deduct Matrix

Extent	Faulting			Cracking			Joint Spalling		
Range	Low	Med	High	Low	Med	High	Low	Med	High
1	5	10	15	5	10	15	5	10	15
2	10	20	30	10	20	30	10	20	35
3	20	30	40	20	35	50	15	30	50

FLEXIBLE PAVEMENT DISTRESSES – WINDSHIELD

1. Fatigue (Alligator) Cracking

Severity:	1 = Low	Discontinuous branched & thin longitudinal cracks
	2 = Medium	Fully developed alligator pattern with some spalling
	3 = High	Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.

1 = 1% - 9%	of both wheel paths
2 = 10%-24%	of both wheel paths
3 = 25%- 29%	of both wheel paths
4 = 50%-or more	of both wheel paths

2. Longitudinal Fatigue Cracking

Severity:	1 = Low	Less than ¼ inch
	2 = Medium	Greater than ¼ inch with Spalling
	3 = High	Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment

1 = 1% -99%	of the length of the segment
2 = 100% - 199%	of the length of the segment
3 = 200% or more	of the length of the segment

3. Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.

1 = 1-4	cracks per 100 ft.
2 = 5-9	cracks per 100 ft.
3 = 10 or more	cracks per 100 ft.

4. Patching – Maintenance

Severity:	1 = Low	Chip seal patch.
	2 = Medium	Blade patch.
	3 = High	Dig-out, Full depth patch.

Extent: Percentage of length of both wheel paths.

1 = 1% - 9%	of both wheel paths
2 = 10% - 24%	of both wheel paths
3 = 25% or more	of both wheel paths

$WSPCR_2$ – Local Agency Windshield Distress Rating System

Introduction

The original $WSPCR_1$ windshield rating procedure was expanded for local agency use to include additional distress types. WSDOT had originally included these distresses in their PCR_1 procedure but stopped their use because they found no correlation with state highway use. This rating procedure has been referred to as the "Local" deduct method in earlier Washington State PMS literature and a separate set of deduct matrices was setup in the WSC2 software for the use of both the PCR_1 (State) or PCR_2 (Local) deduct matrices. The following Figures show the deduct matrices currently used by the CenterLine software for this system. These raveling and flushing deducts are also used with the current detailed walking distress survey (WSC2). Even though this procedure was developed for local agencies by WSDOT research funds, WSDOT has never established or set standards for the use of this system. <u>The numbers given below are being proposed as a standard and were taken from the ASTM curves using the mid-point extent for each extent range</u>.

Objective

This system was developed from the $WSPCR_1$ method with the goal of optimizing its use for local agencies. It was also the first step in the development of a final rating system, which is the WSC2 or Washington State City & County rating system. The WSC2 rating system is outlined later in this document and is the method being proposed for final acceptance for use by the Washington Local Agencies.

Method

The extents associated with all three levels of each distress are grouped, (summed), together into the most predominate severity and the extents are defined using finite ranges of extent and percent wheel path to define the quantity. This allows the rater to quickly make decisions and to quantify the data while driving. This method is also used by some agencies for walking surveys. The data being collected can be put directly onto a form or this system can be easily adapted to an automated type keyboard based system connected directly to a distance-measuring instrument (DMI).

Each combination of severity and extent range is assigned a value, which is called a deduct value. These deduct values are provided in a matrix format and are given below. The proper deduct value is selected for each existing distress type by going to the appropriate matrix and locating the proper extent range and severity row and column and selecting the deduct number located at the point where they meet. These deduct values for each existing distress within a given segment of pavement are then summed together and subtracted from 100 to compute the PCR score.

This score can go below zero and may be truncated or tapered below a given value within your PMS software to account for potential analysis problems. The ASTM rating system defines a tapering or smoothing process which is applied when multiple distress types or severities of a given distress occur within the same segment, which will automatically remove the possibility of negative indices. This is the preferred method even with the $WSPCR_{1\,\&\,2}$ procedures and should be an available option within your PMS software. WDOT has traditionally called this index the Pavement Condition Rating or PCR.

$$PCR_2 = 100 - \sum_i (DeductsValues)_i$$

Recommended Use

This method is used quite extensively in Washington State and is ideal for low budget applications and network level budget planning. This method can be easily expanded, by changing to an actual area and length method of measuring the extent and the recording of data for each severity level. The WSC2 method was developed from this method.

Figure 5a - Extent Ranges Used for each Distress Type

Extent Ranges	Corrugation	Raveling/ Flushing	Block Cracking	Edge Conditions	Rutting
1	0 - %	1% - 99%	> 9'x9'	1-9%	¼" – ½"
2	10% - 24%	99% - 199%	5'x5'- 9'x9'	10-24%	½" – ¾"
3	25% - 49%	200% or more	4'x4' or less	> 25%	> ¾"
4	50% or more	-	-	-	-

Figure 5b - Suggested Flexible Pavement Deducts – Taken from ASTM Deduct Curves

Extent	Alligator Cracks			Longitudinal AC Cracks			Transverse Cracks			Maintenance Patching		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	24	38	52	11	22	45	11	22	45	5	22	37
2	39	56	69	16	31	62	16	31	62	20	41	68
3	44	59	74	29	44	86	29	44	86	50	58	80
4	56	74	87	-	-	-	-	-	-	-	-	-

Extent	Corrugation			Raveling/Flushing			Block Cracking			Edge Conditions		
Range	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
1	15	43	64	5	20	45	10	18	33	5	11	20
2	26	56	80	10	30	65	18	32	55	11	22	40
3	36	70	86	15	40	75	25	40	70	20	40	80

Extent	Rutting			Crack Sealing?		
Range	Low	Med	High	Low	Med	High
1	25	45	60	1-9%	10-25	> 25

Portland Cement Concrete Pavements (PCC)

For PCC streets, the rater is to count each slab containing a given severity level of a given distress. The density is the percent slabs or the number of slabs with a given distress divided by the total number of slabs. The extent ranges are the same for all distress types, except for wear, which is the same as for rutting in flexible pavements. These extent ranges are shown in Figure 6a.

Figure 6a - Extent Ranges Used for each PCC Distress Type

Extent Ranges	Wear	All other Distresses
1	¼” to ½”	1% to 9% slabs
2	½” to ¾”	10% to 24% slabs
3	over ¾”	> 25% of slabs

Figure 6b - Suggested Portland Cement Concrete Pavement Deducts – from ASTM Curves

Extent Range	Raveling			Pumping			Faulting		
	Low	Med	High	Low	Med	High	Low	Med	High
1	6	18	35	10	20	35	5	15	30
2	10	25	48	20	35	45	20	30	50
3	15	30	60	35	45	55	30	50	75

Extent Range	Cracking			Joint Cracking			Patching		
	Low	Med	High	Low	Med	High	Low	Med	High
1	20	35	52	5	10	25	5	10	30
2	35	50	70	10	15	35	15	30	45
3	48	70	85	15	25	50	25	45	65

Extent Range	Wear			Blowups		
	Low	Med	High	Low	Med	High
3	10	20	30	35	70	90

Severity and Extent Summary for $WSPCR_2$ Surveys

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). The extent ranges given below are intended for use in a moving windshield survey. Entry a 1, 2 or 3 into the appropriate severity column on the form for each distress type observed. All severity levels are included in the predominate severity when estimating extent quantities. Rating only the outer lane in one direction is common. Percent length or actual areas & lengths can also be used for measuring the extent.

FLEXIBLE PAVEMENT DISTRESSES

1 Rutting and Wear

Severity: The average rut depth in the wheel path for the segment or sample.

1 = Low ¼ in. to ½in.
2 = Medium ½in. to ¾in.
3 = High over ¾in.

Extent: Assumed to be the full length/area of the surveyed segment.

2 Fatigue (Alligator) Cracking

Severity: 1 = Low Longitudinal cracks.
2 = Medium Fully developed alligator pattern with some spalling
3 = High Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.
1 = 1% - 9% of both wheel paths or by area
2 = 10%-24% of both wheel paths or by area
3 = 25%- 29% of both wheel paths or by area
4 = 50%-or more of both wheel paths or by area

3. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking
4. Longitudinal Reflective Cracks

Severity: 1 = Low Less than ¼ inch
2 = Medium Greater than ¼ inch with Spalling
3 = High Greater than ¼ inch with Spalling and Pumping
Extent: Percentage of the length of the surveyed segment or by length
1 = 1% -99% of the length of the segment or by length
2 = 100% - 199% of the length of the segment or by length
3 = 200% or more of the length of the segment or by length

5. Transverse Cracking
Severity: Same as #3
Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft. or by length
2 = 5-9 cracks per 100 ft. or by length
3 = 10 or more cracks per 100 ft. or by length

6. Raveling and
7. Flushing Rated in same column on form – Place a "F" in the raveling/Flushing flag for flushing and "R" for raveling.
Severity: 1 = Low Slight
2 = Medium Moderate
3 = High Severe
Extent: 1 = Localized
2 = Wheel Paths
3 = Entire Lane

8. Patching – Maintenance
9. Patching – Utility
Severity: 1 = Low Good condition.
2 = Medium Moderately deteriorated – ride medium.
3 = High Badly deteriorated – ride poor.
Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths or by area
2 = 10% - 24% of both wheel paths or by area
3 = 25% or more of both wheel paths or by area
Comments: Utility patching is rated separately

10. Corrugation and Waves
Severity: The maximum deviation from a 10-foot straight edge
1 = Low 1/8-in. to 2-in. change per 10 ft.
2 = Medium 2-in. to 4-in. change per 10 ft.
3 = High Over 4-in. change per 10 ft.
Extent: Same as #9

11. Sags and Humps
Severity: Same as #10
Extent: Same as #9

12. Block Cracking
Severity: Block Size
1 = Low 12-ft. x 12-ft. blocks (9x9 and larger)
2 = Medium 6-ft. x 6-ft. blocks (5x5 to 8x8)
3 = High 3-ft. x 3-ft. blocks (2 x 2 to 4 x 4)
Extent: Assumed to be the full length of the segment.

13. Pavement Edge Condition
Severity: 1 = Low Edge patching extent (severity is undefined)
2 = Medium Edge raveling extent (severity is undefined)
3 = High Edge lane less than 10 feet extent (severity is undefined)
Extent: Percent of twice the segment length.

14. Crack Seal Condition

Severity: 1 = Low Hairline cracks in the sealant allow only minimal water passage.
2 = Medium The crack sealant is open and will allow significant water passage.
3 = High The crack sealant is very open or non-existent.
Extent: Same percentages as #9 but based on the total length of all cracks &/or joints.

RIGID PAVEMENT DISTRESSES – $WSPCR_2$

1. Cracking
   - Severity: Low 1 crack per lane panel.
     - Medium 2 or 3 cracks per panel.
     - High 4 or more cracks per panel.
   - Extent: 1 = 1% to 9% of the slabs are cracked.
     - 2 = 10% to 24% of the slabs are cracked.
     - 3 = 25% or more or the slabs are cracked.
2. Joint and Crack Spalling
   - Severity: Low 1/8-in. to 1-in. spalls.
     - Medium 1-in. to 3-in. spalls.
     - High Greater than 3-in. spalls.
   - Extent: Same as #1.
3. Pumping and Blowing
   - Severity: Low Slight shoulder/lane depression, no staining.
     - Medium Significant depression, slight staining.
     - High Severe depression, significant staining.
   - Extent: Same as #1.
4. Faulting and Settlement
   - Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
     - Medium ¼-in. to ½in. faulting or settlement at joints or cracks.
     - High Over ½in. faulting or settlement at joints or cracks.
   - Extent: Same as #1.
5. Patching
   - Severity: Low Patch is in good condition.
     - Medium Patch show low to medium distress and ride quality.
     - High Patch shows severe distress and poor ride quality.
   - Extent: Same as #1.
6. Raveling or Scaling
   - Severity: Low Aggregate or binder has started to wear.
     - Medium Aggregate and/or binder has worn away & the surface texture is moderately rough.
     - High Aggregate and/or binder have worn away significantly.
   - Extent: Same as #1.
7. Blowups:
   - Severity: Not defined.
   - Extent: Number of occurrences per segment.
8. Wear
   - Low ¼ to ½inch.
   - Medium ½to ¾inch.
   - High over ¾inch.
   - Extent: The extent or wear is assumed to be the full length of the segment.

WSPSC - Washington State Pavement Structural Condition Index Equation Based System

Introduction

This rating system uses the same distress types and descriptions as the $WSPCR_1$ system and was developed as a replacement for this procedure. It uses a series of regression equations developed from field data and is in part based on an attempt at trying to define longitudinal and transverse cracking and patching in terms of equivalent alligator cracking. As stated by its developer, this is not a very robust or rigorous mathematically defendable procedure, however, it meets WSDOT's needs.

Objective

To expand the original PCR_1 procedure to include the use of a continuous method of collecting distress data while providing a smooth path from the PCR_1 method. It also excludes any possibility of including other distresses and thus has been renamed as the "Pavement Structural Condition" index. To account for this the WSDOT currently uses three separate indices, the PSC index, rutting index and ride index.

Method

This system uses a series of equations to compute the resulting score, which is called the Pavement Structural Condition Index (PSC). This system can be used with the above discrete matrix based procedure (the PCR_1) by assigning fixed mid-point extent values for each extent range. The actual percentages associated with the extent for each distress type and severity can also be used with these equations. This actually defines two separate rating methods. The following is a section of computer code used to represent these equations. See the WSDOT publication WA-RD 274.1 for full details on how these equations were developed and documentation on this and the PCR_1 procedures. The objective here is to give the user a quick overview of how the PSC is calculated

Recommended Use

This procedure is intended for monitoring the distresses associated with the structural failure of pavements. Other indices must be used with this index if you wish to monitor or use other distresses in the management of your pavements.

Alligator Cracking

```
EqAC = AL_HGH+(0.445*AL_MED**1.15)+(0.13*AL_LOW**1.35)þ
```

Patching

```
EqPT = PT_HGH+(0.445*(PT_MED * 0.75)**1.15)+(0.13*(PT_LOW * 0.75)**1.35)
```

Longitudinal Cracking

```
EqLC = (0.1*LC_HGH)+(0.445 *(LC_MED*0.1)**1.15)+(0.13*(LC_LOW*0.1)**1.35)
```

Transverse Cracking

```
EqTC = (0.6*TC_HGH)+(0.445 *(TC_MED*0.6)**1.15)+(0.13*(TC_LOW*0.6)**1.35)
EqC = EqAC + EqPT +qLC + EqTC
SegDed = 15.8 * EqC**0.5
IF SegDed > 100 THEN SegDed = 100
PCR = 100 - SegDed
SegDed = Segment Deduct value
  *  - Symbol for multiplication
  ** - Symbol for raising a number to a power
```

Where: (All distress data are entered in % of Wheel Path/length, or count for transverse cracking, the mid-point of the extent range is used for $WSPCR_1$ method)

Alligator Cracking			WSPCR Mid-Point Extent
AL_HGH	=	High severity	37.5%
AL_MED	=	medium Severity	12.5%
AL_LOW	=	Low Severity	4.5%
Patching			
PT_HGH	=	High severity	75%
PT_MED	=	Medium Severity	12.5%
PT_LOW	=	Low Severity	4.5%
Longitudinal Cracking			
LC_HGH	=	High severity	50%
LC_MED	=	Medium Severity	100%
LC_LOW	=	Low Severity	150%
Transverse Cracking			
TC_HIGH	=	High severity	2 Cracks
TC_MED	=-	Medium Severity	50
TC_LOW	=	Low Severity	150

FLEXIBLE PAVEMENT DISTRESSES

1 Fatigue (Alligator) Cracking

Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
2 = Medium — Fully developed alligator pattern with some spalling
3 = High — Severe spalling and pumping

Extent: Percentage of the length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10%-24% of both wheel paths
3 = 25%- 29% of both wheel paths
4 = 50%-or more of both wheel paths

2 Longitudinal Fatigue Cracking

Severity: 1 = Low — Less than ¼ inch
2 = Medium — Greater than ¼ inch with Spalling
3 = High — Greater than ¼ inch with Spalling and Pumping

Extent: Percentage of the length of the surveyed segment
1 = 1% -99% of the length of the segment
2 = 100% - 199% of the length of the segment
3 = 200% or more of the length of the segment

3 Transverse Cracking

Severity: Same as #2

Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft.
2 = 5-9 cracks per 100 ft.
3 = 10 or more cracks per 100 ft.

4 Patching – Maintenance

Severity: 1 = Low — Chip seal patch.
2 = Medium — Blade patch.
3 = High — Dig-out, Full depth patch.

Extent: Percentage of length of both wheel paths.
1 = 1% - 9% of both wheel paths
2 = 10% - 24% of both wheel paths
3 = 25% or more of both wheel paths

$WSPCR_3$ - StreetWise Pavement Rating System

Introduction
In 1996, WSDOT Highways and Local Programs division developed this system for use by smaller agencies, originally under a population of 2500. Rehabilitation funds are associated with the use of this system and the WSDOT plans to expand it's use to Cities of 5000 population and eventually even larger Cities.

Objective
The primary objective of this system was to provide smaller local agencies with a simplified rating method that could be applied using paper and pencil methods.

Method
This system uses alligator cracking plus one of four possible secondary distresses to define its pavement score index. It uses a series of score based matrices to compute the score and quantifies the distresses in a similar manner as in the PCR_1 procedure. See the WSDOT StreetWise Manual for full details. This manual states that the current NWPMA/WSDOT Raters manual is to be used for the distress survey, however, it should be noted that it uses a mixture of the method A & method B definitions for how the extents are quantified. Specifically, raveling and patching are measured by actual area of distress and not as a percentage of the wheel path.

It sums all extent values together to compute the density and assigns this value to the predominate severity level, the same as in previous WSDOT procedures. It also uses the same 5 (instead of 3, 4 for alligator cracking) extent levels for all distress types. The procedures for computing the distress density for each distress type are shown below.

Recommended Use
This system is only recommended for use by smaller agencies. The WSDOT is currently in the process of computerizing this system and placing it on the Internet. At that time they also plan to consider the possibility of changing to the distress rating procedures recommended by this committee.

FLEXIBLE PAVEMENT DISTRESSES

Extent ranges for all distresses:

1 = 0% - 1%
2 = 1% - 5%
3 = 5% - 10%
3 = 10% - 25%
4 = 25%-or more

1. Fatigue (Alligator) Cracking

Severity: 1 = Low — Discontinuous branched & thin longitudinal cracks
2 = Medium — Fully developed alligator pattern with some spalling
3 = High — Severe spalling and pumping
Extent: Measure wheel path length containing distress
Density : (Length of wheel path with distress / twice the segment length) x 100

2. Longitudinal Fatigue Cracking - Rate as low severity Fatigue cracking

Severity: 1 = Low — Less than ¼ inch
2 = Medium — Greater than ¼ inch with Spalling
3 = High — Greater than ¼ inch with Spalling and Pumping
Extent: Measure wheel path length containing distress
Density : (Length of wheel path with distress / the segment length) x 100

3. Transverse Cracking

Severity: Same as #2
Extent: Frequency, counts per 100 feet.
1 = 1-4 cracks per 100 ft.
2 = 5-9 cracks per 100 ft.
3 = 10 or more cracks per 100 ft.
Density : (Number of cracks per 100 feet / the segment length) x 100

4. Raveling

Severity: 1 = Low — Slight
2 = Medium — Moderate
3 = High — Severe
Extent: Area of ravel for each severity level
Density : (Area of distress / the segment area) x 100

5. Patching – Maintenance

Severity: 1 = Low — Chip seal patch.
2 = Medium — Blade patch.
3 = High — Dig-out, Full depth patch.
Extent: Area of ravel for each severity level
Density : (Area of distress / the segment area) x 100

WSC2 – Washington State City & County Rating System

OR

Modified ASTM System

(This method is being proposed as a Standard for Local Agencies)

Introduction

To better meet the needs of local agencies and to make better use of automated rating procedures and to address the needs of managing routine and preventative maintenance operations, an extension to the original $WSPCR_2$ procedures has been developed and successfully implemented over the past 16 years. This rating procedure is referred to as the Washington State City and County rating system (WSC2) and is a natural expansion of the original $WSPCR_2$ method and provides the ability to measure the extent of the various distress types in greater detail and thus allow for the use of continuous deduct curves. It also provides access to several additional distress types not available in the PCR_1 and PSC methods. This system currently uses the ASTM system and associated deduct curves with minor changes and was developed by the local agencies themselves. However, modifications to these curves are being recommended. A method for doing this is given in Appendix A. The above changes to the ASTM rating procedures are included below.

The question as to why not just use the current ASTM standard, obviously presents itself here. The following materials show the differences and exemplify the main reasons for further development of the system being proposed here. Of primary concern, is that the WSC2 distress descriptions and the method of quantifying them have developed out of years of experience by both the WSDOT and the Washington State local agencies and reflect this experience and associated needs. A second point of interest is that all of the pavement distress indices discussed to this point, including the ASTM method, are an arbitrary type index (or indicator) and cannot be developed or verified in mathematical or scientific type form or through rigorous experimentation. The original development of the PAVER/ASTM deduct curves was done through the personal judgment/opinion of a handful of pavement related experts from the State of Illinois area in the late 1970's, who I'm sure would agree that they need to be revisited and revaluated. Why step back in time and loose the many years of experience, which has gone into the current system. The WSC2 system also provides compatibility with the WSDOT's current rating methods and index calculation (the PSC). The PSC also provides a reasonable index for statewide comparisons and reporting purposes if it is only applied to State Highways and local agency arterial roadways.

<u>The following items are differences in the WSC2 method from the ASTM system, which are included in the current NWPMA/WSDOT Raters manual and need to be documented and maintained as is</u>:

1. There are differences in the distress descriptions and in the relevant severity and extent definitions.
2. Transverse and longitudinal non-fatigue cracking is rated as two separate distresses
3. A separate longitudinal fatigue crack distress type is included
4. Rutting extent is assumed to be the full segment area and only the average depth is recorded.
5. Edge raveling has been expanded to include edge patching & edge lane width less than 10 feet. The current implementation defines edge patching as medium level ASTM edge raveling, edge raveling as low and lane < 10' as high
6. Raveling and Flushing are rated using the predominate severity matrix method. This is actually an option if the conversion factor portion of this proposal is included.
7. Crack seal inventory/rating is included
8. Several of the ASTM flexible distress types have not been included. These are distress type numbers 6, 8, 9, 12, 13, 14, 16, 17, 18. These are the numbers ASTM has assigned to each distress (See Figure 7).

The following is a list of additional variations from the current ASTM procedures which need to be included and added to the current NWPMA/WSDOT Pavement Raters Manual in the form of an addendum along with the above eight items. The primary reason for item #2 below is to address the use of the rating data to drive an agency's routine maintenance operations, primarily crack sealing and patching. The response to this method of rating patching, is often stated as patching is being rated twice. This can best be accounted for in the deduct curves. However, without this modification it is impossible to properly manage maintenance operations or model the cost estimates for maintenance.

9. Utility patching is included as a separate distress
10. Rate all distresses as if patching doesn't exist & then rate the condition of the patch separately
11. 100% sampling is recommended in all cases & not the 10%-to-100% sampling option as specified by ASTM standard. Single lane sampling will be allowed.

Where needed, use the current CenterLine Distress Rating Manual (See Appendix E) as a guide for defining any needed definitions, etc. This manual contains the original descriptions developed by the Local Agencies. Consideration should also be given to/for allowing all deduct curves and related units of extent to be adjustable/modifiable by the user, while establishing a standard set of deduct curves, which could be used for statewide comparisons. This is similar to the separate "State" and "Local" deduct matrices used in the original Washington State Local Agency PMS (WSC2-PMS). At a minimum, adjust the deduct curves for the distress types marked in Figure 7.

Consideration should also be given to adding the following items to the addendum to the current rating manual or any future changes to the current raters manual.

- Consider changing the wording for Alligator cracking to read "Alligator (Fatigue) cracking"
- Replacing "Longitudinal Cracking" with "Longitudinal Fatigue Cracking"
- Replacing "Longitudinal non-wheel path cracking" with "Longitudinal non-fatigue cracking".
- Change raveling & flushing in BST pavements. It should be rated as such and not reversed.
- Consider adding ride, profile/roughness and some measure/index for drainage.
- The use of both sample unit and full area sampling must be allowed for in the implementation of this procedure.
- The ability to change extent units of measure from one year to the next.
- This recommended rating procedure should be published as an actual WSDOT report, in the same way as the StreetWise rating procedure or PaveSmart System (M 36-64), and not just as an endorsement through the NWPMA as with the past raters manuals. This is the only way the problems associated with the last 15 years can be avoided in the future and that we can be assured that this issue will not be revised in the future. This will also establish this as an official endorsement by the WSDOT.

This system was developed over a 16-year period of application, starting in 1985, by local agencies within the northwest through joint research at the University of Washington, local agency user groups and the WSDOT. It reflects the needs and requirements of these local agencies while still allowing for full compatibility with WSDOT's current rating operations. This system is currently being used by most of the larger Cities and Counties within the State and was developed out of an attempt by state and local agencies to establish a statewide standard uniform rating system.

Objective
To provide the detail and flexibility in a rating system that would allow its use by all local agencies.

Method
The detailed distress rating description and procedures associated with the WSC2 method are provided in the CenterLine PMS Raters Manual (which is included as part of this recommendation in Appendix E) and are summarized in the following outline. In general these agree with the NWPMA manual, they actually both came from the same origin. This system combines the $WSPCR_2$ (Washington State Local Agency windshield rating system) and the ASTM systems and makes the best use of each. It is designed to provide for the varying needs of both large and small local agencies and is adaptable to automated rating systems. The primary difference between the original $WSPCR_{1\&2}$ systems and the WSC2 system is that several distress types have been added and the method of measuring the extent has been redefined to allow for detailed measurement of individual severities for each distress type. This also allows for the use of continuous deduct curves in place of the matrices now in use in the $WSPCR_{1\&2}$ calculations.

Also the distress quantification method used for raveling and flushing has not changed from the original $WSPCR_2$ procedures as defined by the local agency. The descriptions for patching has been modified to allow for local agency needs while still providing compatibility with the WSPSC system. Also, longitudinal fatigue cracking, and utility patching have been added.

The following section outlines the distress types and the way in which they are quantified and recorded. Please see the NWPMA rater's manual and Appendices A through E of this manual for more details.

Recommended Use
This system is recommended for use by all agencies large and small. It is especially applicable for the development of detailed and accurate rehabilitation and reconstruction project lists as well as for managing preventative and routine maintenance operations. It helps add to the use of your PMS as a project tool as well as for network planning.

Severity and Extent Summary for WSC2 Surveys for flexible pavements
The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist).

FLEXIBLE PAVEMENT DISTRESSES

1. Rutting and Wear
   - Severity: Average Rut Depth over the segment.
   - Extent: Assume full segment length.
   - Data Entry: Single entry in 0.25 inch increments to right of description.
   - Comments: Estimate mean rut depth in inches. Use sags and humps for localized rutting.
2. Fatigue (Alligator) Cracking
   - Severity: (Crack size and Pattern)
     - Low: Branching inner connecting longitudinal cracks.
     - Medium: Fully developed alligator pattern with some spalling
     - High: Severe spalling and pumping
   - Extent: Entry the area of each severity in sq. units.
3. Longitudinal Cracking - Fatigue (Structurally) Related
   - Severity:
     - Low: Less than ¼ inch crack wide
     - Medium: Greater than ¼ inch crack wide.
     - High: Greater than ¼ in. Spalled cracks.
   - Extent: Enter the length in feet – enter separately for each severity

Comments: Fatigue caused longitudinal cracks are the early or first stage of distress #2. These cracks have a distinct broken pattern and occur in the wheel path.

4. Longitudinal Cracking - Non-Structural - Joint Reflective and Construction Joint - Quantify the same as in #3

Comments: This distress tends to be straighter and has more distinct cracks than longitudinal fatigue/alligator cracks

5. Transverse Cracking - Quantify the same as in #3

Comments: Include localized alligator cracking in the transverse direction as high transverse cracks.

6. Raveling

Severity: Low Binder &/or aggregate has started to wear away.
Medium Binder &/or aggregate has worn away and is rough.
High Surface texture is deeply pitted.

Extent: Localized 1 – Isolated patches of raveling.
Wheel paths 2 – Both wheel paths are fully raveled.
Entire lane 3 – Complete surface is raveled.

Data Entry: Enter predominate extent & severity to right of description – ex 2M=wheel path medium severity.

7. Flushing or Bleeding

Severity: Low Minor amount of aggregate is covered
Medium Significant amount of aggregate is covered
High Most of the aggregate is covered

Extent: Same as #6

Comments: Rate raveling and flushing separately.

8. Patching – Maintenance

Severity: Low Good condition.
Medium Moderately deteriorated – ride medium.
High Badly deteriorated – ride poor.

Extent: Entry the area in square feet for each severity.

Comments: Utility patching is rated separately.

9. Patching – Utility: Rated the same as #8, maintenance patching

10. Corrugations and Waves

Severity: Low 1/8 in. to 2 in. change per 10 feet.
Medium 2 in. to 4 in. change per 10 feet.
High Over 4 in. change per 10 feet.

Extent: Enter the area in square units for each severity.

11. Sags and Humps - Same as #10

12. Block Cracking

Severity: Low 9x9 foot and larger blocks.
Medium 5x5 to 9x9 foot blocks.
High Greater then 9x9 foot blocks.

Extent: Enter the area in sq. feet for each severity.

13. Edge Condition

Severity: Low = Edge Raveling
Medium = Edge Patching
High = Lane less than 10 feet
Extent: Enter the accumulated lengths for each severity.

Comment: Rate both sides of the street.

14. Crack Seal Condition

Severity: Low Crack sealant is in good condition.
Medium Crack sealant is open and allows water into crack.
High Crack sealant is missing or non-existent.

Extent: Percent of total cracks that are sealed. Enter percentage for each severity.

Comments: Example: 50L, 25M = 50% are sealed & in low condition plus 25% in medium condition. 25% are not sealed.

15. Ride Quality

This is generally not collected with a walking survey, however, if desired assign a number from one to ten with one being a perfect ride and 10 being the worst. If automated equipment is used, enter the mean IRI

(International Roughness Index) value. You may also want to record the maximum, minimum and standard deviation values.

16. Drainage Index

    This is generally not collected, however, if desired assign a number from one to ten with one being a good drainage score and 10 being the worst.

Note: Distresses 1, 6, 7, 14, 15 and 16 are entered on the center portion of the form to the right of the distress name itself. All of the other distresses are entered into the lower portion of the form by placing the number associated with the distress being measured at the top of the column and accumulating the various amounts of the distress in the cells below. The final amount (extent) of each distress is then totaled at the bottom of the form. There is also a place at the bottom of the form for the previous years rating data, which is included if available.

Severity and Extent Summary for WSC2 Surveys for rigid pavements

(This is the WSDOT method, the ASTM system may be considered and is included in this proposal)

The following is a summary of each pavement distress type and its quantification in terms of severity (how bad the distress is) and extent (over what area/length does it exist). In distresses 1 through 6 extent is defined as the number of slabs containing a given distress while #7 is an individual count/event and #8 is an average depth.

1. Cracking
   - Severity: Low 1 crack per panel
     - Medium 3 cracks per panel
     - High 4 or more cracks per panel
   - Extent: Enter the number of slabs for each severity (Same for distresses 1 throught 6)
2. Joint and Crack Spalling
   - Severity: Low 1/8-in. to 1-in. spalls
     - Medium 1-in. to 3-in. spalls
     - High Greater than 3-in. spalls
3. Pumping and Blowing
   - Severity: Low Slight shoulder depression, no staining
     - Medium Significant depression, slight staining
     - High Severe depression, significant staining
4. Faulting and Settlement
   - Severity: Low 1/8-in. to ¼-in. faulting or settlement at joints or cracks.
     - Medium ¼-in. to ½in. faulting or settlement at joints or cracks.
     - High Over ½in. faulting or settlement at joints or cracks.
5. Patching
   - Severity: Low Good condition.
     - Medium Moderately deteriorated – ride medium.
     - High Badly deteriorated – ride poor.

3. Raveling or Scaling
   - Severity:
     - Slight Aggregate and binder has started to wear away.
     - Moderate Aggregate and/or binder has worn away & surface texture is moderately rough
     - Severe Aggregate and/or binder have worn away significantly.
4. Blowups
   - Severity: Not defined
   - Extent: Number of occurrences per segment
5. Wear
   - Severity: Enter mean depth to nearest ¼"
   - Extent: The extent of wear is assumed to be the full length of the segment.

Distress Rating Index Computations/Procedures

The ASTM deduct curves are currently used with the WSC2 procedure for computing the resulting score. Figure 7a shows the ASTM curves currently used by the WSC2 system. Other "Deduct Curves" could be developed or these could be modified. The ability to do this, along with proper guidelines on how to do this should be included in your PMS software and in this proposed standard. See Appendix A.

Figures $8_{a\&b}$ shows the conversion factors which are currently available in the CenterLine software and which are provided so as to allow for variations between different users and most importantly to provide a mechanism for allowing a given agency to change the way in which they measure the extent of any given distress from one year to the next. This feature is included in the recommendation for a final rating system. Another important advantage of this feature is that it allows methods A & B, which are in the current NWPMA/WSDOT Raters Manual, to be combined into a single rating score index algorithm. Therefore, this feature along with the ability to modify the deduct curves would give the end user the ultimate flexibility in using the proposed standard to meet any current or future needs or changes in their rating procedures. This is the single most important aspect of any new statewide rating standard, in that if it can't meet an agency's current or future needs they will most likely modify the system on their own or fail to make effective use of it.

Figure 7a - WSC2 - DEDUCT CURVE SUMMARY – Flexible Pavements

WSC2		ASTM	
#	**Distress Type**	**#**	**Curve Used**
1	Rutting *	15	$WSPCR_2$ Matrix
2	Fatigue Cracking	1	Alligator Cracking
3	Longitudinal-Fatigue Cracks *	1	Alligator Low for all severities #
4	Longitudinal-Reflective Cracks	10	Transverse & Longitudinal
5	Transverse Cracking	10	Transverse & Longitudinal
6	Raveling	19	WSDOT Deduct matrix - $WSPCR_2$
7	Flushing	2	WSDOT Deduct matrix - $WSPCR_2$
8	Patching -Maintenance	11	Patch & Utility Cuts
9	Patching – Utility *	11	Patch & Utility Cuts
10	Corrugations & Waves	5	Corrugation
11	Sags & Humps	4	Bumps and Sags
12	Block Cracking	3	Block Cracking
13a	Edge Raveling	7	Edge Cracking Medium
13b	Edge Patching	7	Edge Cracking Low
13c	Edge Lane < 10'	7	Edge Cracking High
14	Crack Seal Condition	-	Inventory only
15	Ride Index	-	N/A
16	Drainage Index	-	N/A

* These distress types need new or modified deduct curves or deduct values

\# A one foot width is assumed and all severities are summed together and added to the low level alligator (fatigue) cracking.

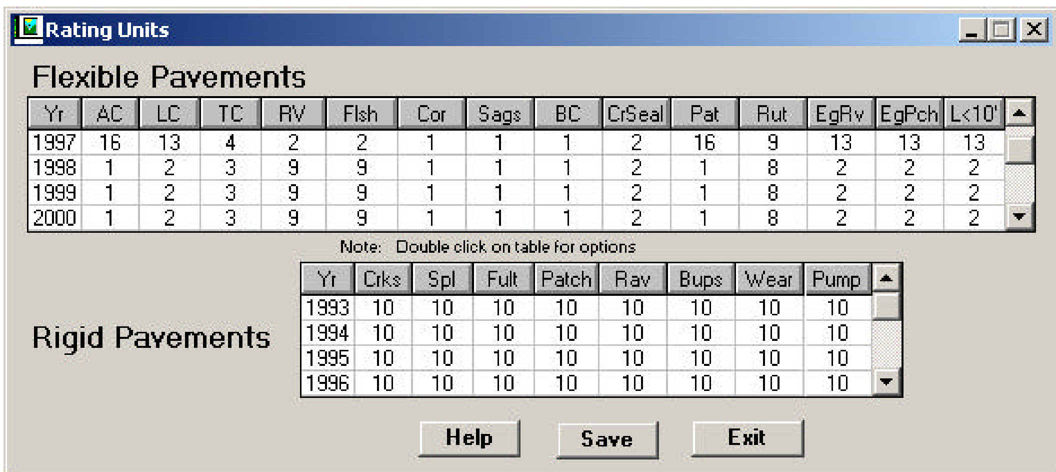
Figure 7b - WSC2 - DEDUCT CURVE SUMMARY – Rigid Pavements

WSC2		ASTM	
#	**Distress Type**	**#**	**Curve Used**
1	Cracking *	24	Durability "D" Cracking*
2	Joint & Crack Spalling	39	Spalling
3	Pumping & Blowing	33	Pumping
4	Faulting and Settlement	25	Faulting
5	Patching	29	Patching, Large & Utility Cuts
6	Raveling or Scaling	36	Scaling/Map Cracking/Crazing
7	Blowups	21	Blow-Up, bucking/Shattering
8	Wear		

Note: The ASTM system could be used for PCC in place of the WSDOT.

* Should change this to Linear or Divided slab deduct curves?? (2/2002 meeting)

Figure 8a Setup screen for defining rating distress quantification/conversion units


Rating Units

Flexible Pavements

Yr	AC	LC	TC	RV	Flsh	Cor	Sags	BC	CrSeal	Pat	Rut	EgRv	EgPch	L<10'
1997	16	13	4	2	2	1	1	1	2	16	9	13	13	13
1998	1	2	3	9	9	1	1	1	2	1	8	2	2	2
1999	1	2	3	9	9	1	1	1	2	1	8	2	2	2
2000	1	2	3	9	9	1	1	1	2	1	8	2	2	2

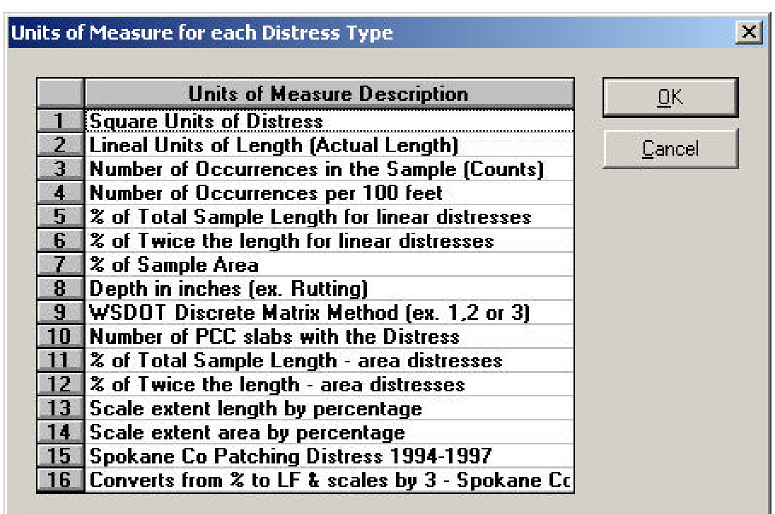
Note: Double click on table for options

Rigid Pavements

Yr	Crks	Spl	Fult	Patch	Rav	Bups	Wear	Pump
1993	10	10	10	10	10	10	10	10
1994	10	10	10	10	10	10	10	10
1995	10	10	10	10	10	10	10	10
1996	10	10	10	10	10	10	10	10

Help   Save   Exit

Figure 8b Available extent unit quantification options


Units of Measure for each Distress Type

	Units of Measure Description
1	Square Units of Distress
2	Lineal Units of Length (Actual Length)
3	Number of Occurrences in the Sample (Counts)
4	Number of Occurrences per 100 feet
5	% of Total Sample Length for linear distresses
6	% of Twice the length for linear distresses
7	% of Sample Area
8	Depth in inches (ex. Rutting)
9	WSDOT Discrete Matrix Method (ex. 1,2 or 3)
10	Number of PCC slabs with the Distress
11	% of Total Sample Length - area distresses
12	% of Twice the length - area distresses
13	Scale extent length by percentage
14	Scale extent area by percentage
15	Spokane Co Patching Distress 1994-1997
16	Converts from % to LF & scales by 3 - Spokane Cc

OK   Cancel

Density equations for each unit of Extent option

The following are the actual equations associated with each of the unit density conversion options given in Figure 8b. Some of these are only applicable to a given agency and changes they've made in their past rating methods, such as numbers 13 through 16. These density conversion options can be applied independently to each survey year. Thus an agency can change the way they collect their rating data from one year to the next. This not only allows the moving from say a windshield type survey to a walking survey but it allows for more subtle changes such as changing from a wheel path extent measure to actual area or from one lane to the total segment area or manual to automated. This allows for the continuity in your data following such changes and thus provides for the use of this past data in the development of your default/family curves as well as for the development of your individual project performance curves. This option also allows the Methods A & B in the current NWPMA/WSDOT Raters Manual to be combined into one distress score algorithm or procedure. This system also allows for the use of both sample unit type data collection as well as the full segment area. The minimum recommended sample unit is one lane the full length of the segment. Therefore, the "Area" in the equations is the sample unit area (for full area sampling this would be the full segment area). In options 14 & 15 the "Su_" references the sample unit measures.

1.	Square Units of Distress	density = distress / Area
2.	Linear Units of Lengths	density = distress / Area
3.	Number of Occurrences in sample	density = (distress*(0.75*Su_Width)) / Area
4.	Number of occurrences per 100 feet	density = (distress*(Length/100)*(0.75*Su_Width))/Area
5.	Percent of sample length for linear	density = ((distress/100)*Length) / Area
6.	Percent of twice the length for linear	density = ((distress/200)*Length) / Area
7.	Percent of sample area	density = distress
8.	Depth in inches	density = (distress/3) / Area (3 inch rut = max deduct)
9.	Discrete matrix method	Uses matrices
10.	Number of PCC slabs	density = (distress/total slabs) / Area
11.	Percent of total sample length (area)	density = (((distress/100)*Length)*(Width/2)) / Area
12.	Percent of twice the length, area only	density = (((distress/200)*Length)*(Width/2)) / Area
13.	Scale extent length by percentage –	density = ((distress/100)*Length) / Area)
14.	Scale extent area by percentage –	density = ((distress/100)*Su_Area) / Area
15.	Spokane County Patching 1994-1997	density = ((distress*(2*Su_Width / Width)) / Area
16.	Convert % of linear feet & scale by 3	density = (((distress*(Length*2))/100)*3) / Area
17.	"3A" Longitudinal fatigue cracks	density = ((distress/4) / Area), if %, use density= distress

Final percent density = density*100

The ASTM density calculations are defined as follows:

1. Area type distress quantities = distress area / total sample area * 100

2. Length distress extent quantities = distress length / total sample area * 100

3. Counted distress extent quantities = distress count / total sample area * 100

Detailed steps in performing the WSC2 index calculations

See Figure 9 for a graphic display of the steps required in computing the final index score. This is actually an extremely simple process once the deduct curves and the related correction process is defined. The following is a summary of the steps in Figure 9.

1. Compute proper density for each distress data item. See Figure 8.
2. Obtained the deduct values for each severity level of each distress. See Figures 7, A4 & A5.
3. Correct the deduct value using the ASTM Q-Curve correction algorithm (See Appendix B)
4. Compute the final score by subtracting the final corrected deduct value from 100

Summary and Recommendations

This system has been successfully implemented by most of the Cities within the State, which currently have operating PMS systems and by four counties. This procedure tends to provide different scores then the $WSPCR_{1\text{ or }2}$ methods, due primarily to the fact that there is more distress types included in the WSC2 method. This fact could be addressed by adjusting the deduct values in the $WSPCR_{1\text{ or }2}$ or by modifying the deduct curves in the WSC2 method if desired or by setting the desired index distress options in the CDI, CSI or CNI setup. Also, the use of discrete extent ranges tends to decrease the scores, apparently due to the tendency to place marginal extent quantities into the next higher range and due to the fact that a large percentage of street segments tend to have 1 or 2% of a given distress severity and these get lumped with higher distressed pavements because of the size of the initial or first extent category also the deduct curves have a cutoff o 1% in most cases and distress extents below this are not included. Therefore, care should be taken when making the transition if an agency is currently using WSPCR ratings procedures. This is also true for the WSPSC method. This can also affect your historical distress data and the resulting performance curves if you do switch from one system to the other. However, in most cases the historical data is maintained with your PMS database and these scores can be recomputed.

The greatest advantage of the WSC2 method is the increased accuracy and detail in the data. This helps to provide more consistent data from survey-to-survey and allows for the better management and modeling of routine and preventative maintenance and other repair operations, such as your preparation costs associated with an overlay or seal coat. It also provides for a better selection/prioritization of rehabilitation projects. See Appendix D for more details.

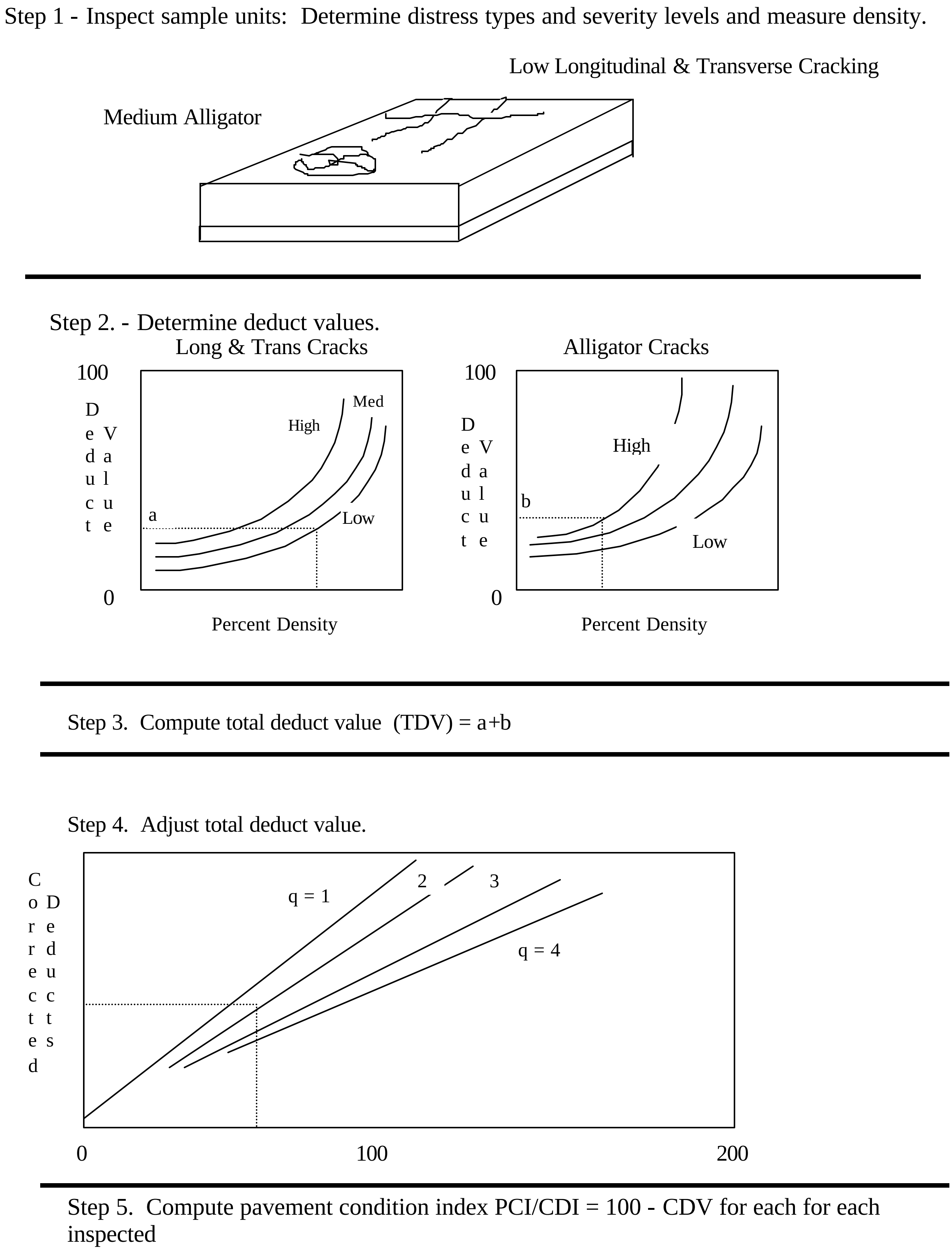


Figure 9 – ASTM/WSC2 rating procedure diagram

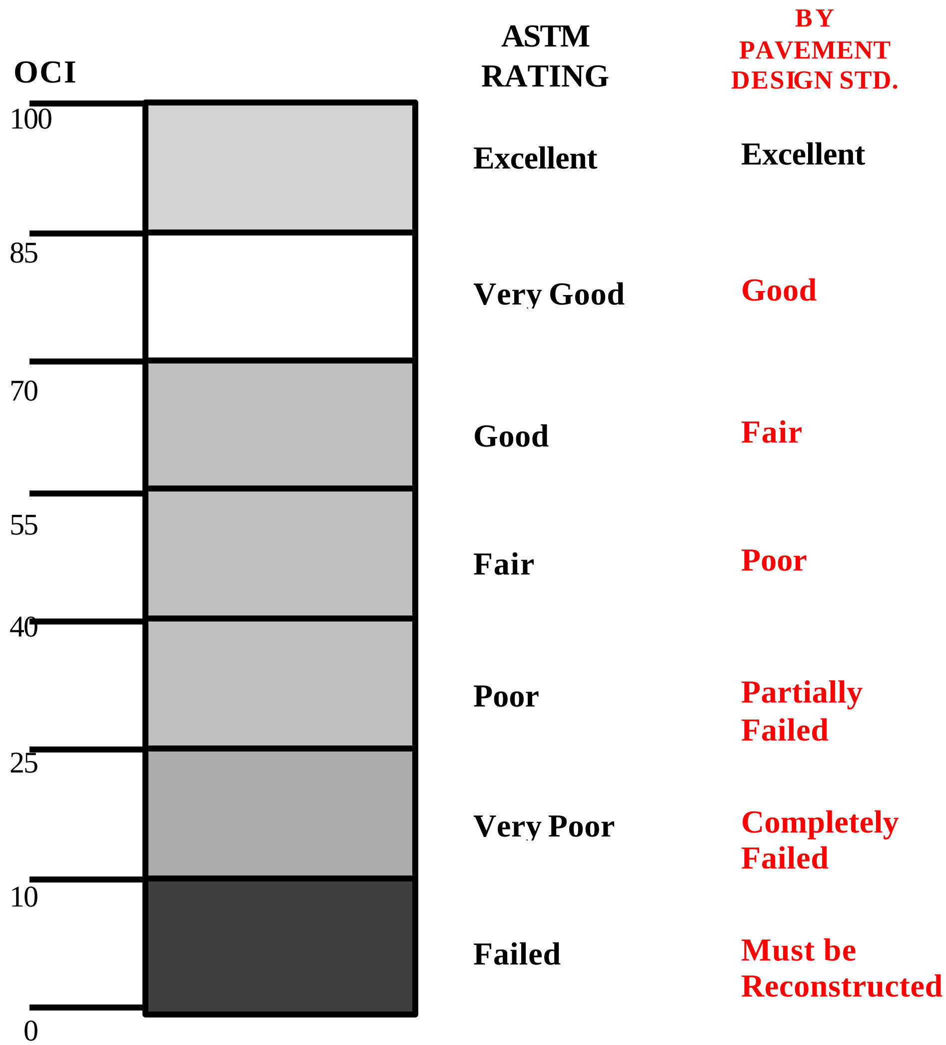


Figure 10 - OCI/PCI - Scale and Condition Rating

Note: This scale is used quite extensively in the literature and the ASTM standard. However, it is quite misleading when compared to standard excepted pavement design procedures. In this figure the scale to the farthest right side is more representative of the true nature of the actual condition of the pavement.

Multiple Distress Index Options

To allow the software to use all the above indices and the various options associated with them in a single program, and to allow for understandable documentation, three separate and new index definitions are being proposed; the CDI, CSI and CNI. This also allows for the separate modeling/curve fitting of each, along with the option to use anyone of them to drive your PMS. Further, within the software the individual distresses included within each are definable by the user. Separate indices for distress (all, structural & non-structural), ride, rutting, skid/profile/roughness and NDT structural will also be included. These new indices along with the original are defined below.

The need for more than one index in the management of an agency's pavements should be obvious from the preceding discussions. To accommodate this, the following different indices are being proposed. It may be advisable to consider others, such as a drainage index, frost index, etc. The WSDOT currently uses separate indices for structural distress (PSC), ride and rutting.

Proposed indices:

- **OCI** **Overall Composite/Combined Index**- This index can be defined separately for each pavement type and functional classification and can be defined as a weighted combination of the following seven indices. Generally this index is set equal to the CDI.
- **CDI** **Combined Distress Index** – this index is comparable to the ASTM PCI and the WSDOT "Local Agency $\mathbf{PCR_2}$" indices depending on how your CenterLine rating system is set up. Within the CenterLine software the CDI is in general a combination of the CSI and CNI.
- **CSI** **Combined Structural Index** – This index can be computed and used in two different ways within the software. It can be set to use the **PSC** equations or it can be computed from the standard ASTM deduct curves. This allows for full compatibility with WSDOT procedures. The user can select the individual distresses used in computing this index when using the CSI. Generally the CSI is set up to correspond to the $\mathbf{PCR_1}$ by the cities and as the PSC by the counties.
- **CNI** **Combined Non-Structural Index** – This index is used to model the non-structural or environmental distresses such as raveling, reflective cracking etc. The CNI and CSI can be used in the PMS repair strategy process to make decision on MR&R actions.
- **RTI** **Rutting index –** This is a separate index, but rutting can also be included in the CDI, CNI and/or CSI indices. Is automatically computed if data is present. This applies to the RDI, NSI and SKI as well.
- **RDI** **Ride index –** The International Ride Index (IRI) can be used here. However, other considerations are possible.
- **NSI** **NDT Structural index** – This index can be defined by different variables. The two key variables that must be included are the deflection basin area and the ASHTO structural number. Continued research related to the development and use of this index is currently being done through interactive work with both Spokane and Pierce County. This index has the potential of becoming the most important index for defining and managing your pavement MR&R activities. This is because what all the other indices are attempting to do is tell you when to perform MR&R operation, while the real indicator of this is the structural properties/condition of your roadway, which defines the actual structural remaining life of a given pavement along with defining your rehabilitation or reconstruction thickness data. This data is provided by this index and the data required in developing it. The only reason it is not currently used by most agencies is that the data required is more costly.

- **SKI** **Skid or roughness index –** Skid resistance and roughness are in general two different distresses or variables, the skid is an expensive measurement and requires special equipment. The use of roughness or profile for this index is the preferred option.

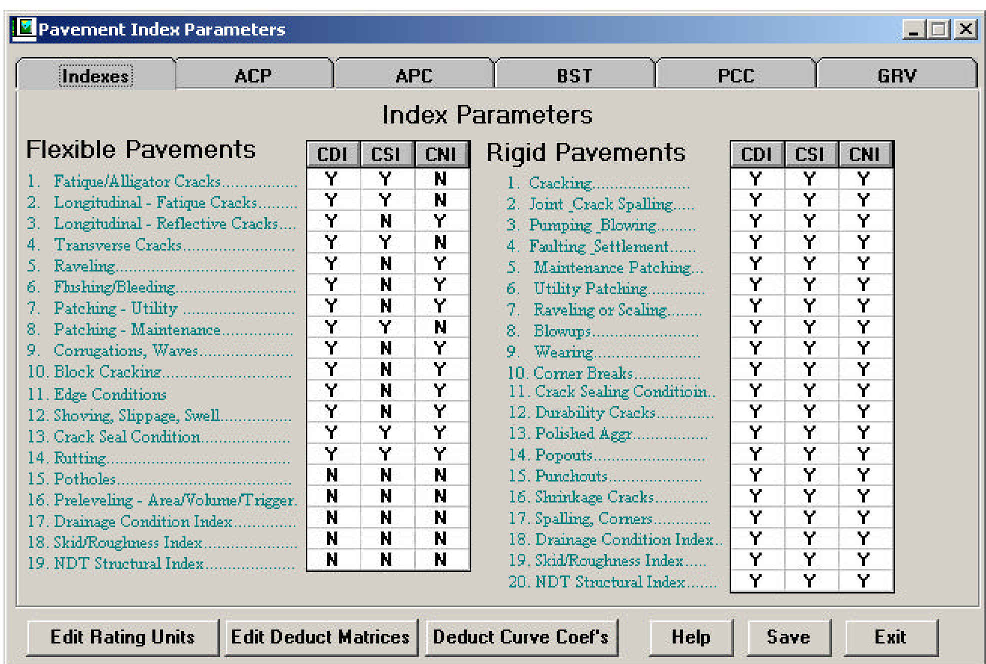
Original Indices:

- **PSC** **Pavement Structural Index** – This index is included in the CenterLine PMS and can be used in place of the CSI. It can also be used to define the OCI.
- **PCR_1** **Original WSDOT method**
- **PCR_2** **Local Agency Windshield method -**
- **PCR_3** **StreetWise Condition Index** – This index is also included in CenterLine PMS.

It is recommended that the CDI (possibly the PSC if just state routes and arterials are included) be used for any state wide comparisons, while defining the final rating system in such a manner as to allow for all past indices to be compute from the same procedures or standard algorithm.

Multiple Index Definition and Control

The above indices are user definable within certain limitations and guidelines. First the distresses included in the combined distress indices, the CDI, CSI and CNI, are user definable. An example of how these are most generally set up is shown in Figure 11 below. The CSI is intended to contain the structural or fatigue related distresses, the CNI the non-fatigue related and the CDI contains all pavement surface distresses. The rutting can be included with the combined distress indices or it can be left out and used only in the separate rutting index (RTI). The rutting index is calculated automatically if data is present. This is also true for all the other non-combined distress indices.



Pavement Index Parameters

Indexes | ACP | APC | BST | PCC | GRV

Index Parameters

Flexible Pavements	CDI	CSI	CNI
1. Fatigue/Alligator Cracks	Y	Y	N
2. Longitudinal - Fatigue Cracks	Y	Y	N
3. Longitudinal - Reflective Cracks	Y	N	Y
4. Transverse Cracks	Y	Y	N
5. Raveling	Y	N	Y
6. Flushing/Bleeding	Y	N	Y
7. Patching - Utility	Y	N	Y
8. Patching - Maintenance	Y	Y	N
9. Corrugations, Waves	Y	N	Y
10. Block Cracking	Y	N	Y
11. Edge Conditions	Y	N	Y
12. Shoving, Slippage, Swell	Y	N	Y
13. Crack Seal Condition	Y	Y	Y
14. Rutting	Y	Y	Y
15. Potholes	N	N	N
16. Preleveling - Area/Volume/Trigger	N	N	N
17. Drainage Condition Index	N	N	N
18. Skid/Roughness Index	N	N	N
19. NDT Structural Index	N	N	N

Rigid Pavements	CDI	CSI	CNI
1. Cracking	Y	Y	Y
2. Joint _Crack Spalling	Y	Y	Y
3. Pumping _Blowing	Y	Y	Y
4. Faulting _Settlement	Y	Y	Y
5. Maintenance Patching	Y	Y	Y
6. Utility Patching	Y	Y	Y
7. Raveling or Scaling	Y	Y	Y
8. Blowups	Y	Y	Y
9. Wearing	Y	Y	Y
10. Corner Breaks	Y	Y	Y
11. Crack Sealing Conditioin	Y	Y	Y
12. Durability Cracks	Y	Y	Y
13. Polished Aggr	Y	Y	Y
14. Popouts	Y	Y	Y
15. Punchouts	Y	Y	Y
16. Shrinkage Cracks	Y	Y	Y
17. Spalling, Corners	Y	Y	Y
18. Drainage Condition Index	Y	Y	Y
19. Skid/Roughness Index	Y	Y	Y
20. NDT Structural Index	Y	Y	Y

Edit Rating Units | Edit Deduct Matrices | Deduct Curve Coef's | Help | Save | Exit

Figure 11. Combined Index Setup Form

The user can define the scale and range associated with how the data is collected for each of the proposed seven indices. No matter how each is set up, the actual internal index is stored and maintained in a normalized form where they all vary from 0 to 100 with 100 being the best or new condition of the variable/s being defined by the given index. This allows all indices to be compared and worked with, from within the software and related analysis and reporting operations in an easier and more consistent fashion. See Figure 12 for details on how this is done. The "Factor "column defines the OCI, which is a weighted average of the other indices. As shown here the OCI is equal to the CDI. All factors must add to 1.0, therefore, if you set the CDI factor to 0.6 and the RTI factor = 0.4, the OCI would be 60% influenced by the CDI and 40% by the RTI or rutting index. The "Worst" and "Best" columns define the upper and lower limits of the variable/s, which define a given index. The "Worst" value can be greater than the "Best". The "LMY Source" radio buttons define which curve to reference the others to when doing the curve fitting operations. All of the non-combined indices could actually be used for any user-defined purpose. Fitted curves are maintained for all indices and anyone or combination of them can be used in driving your PMS.

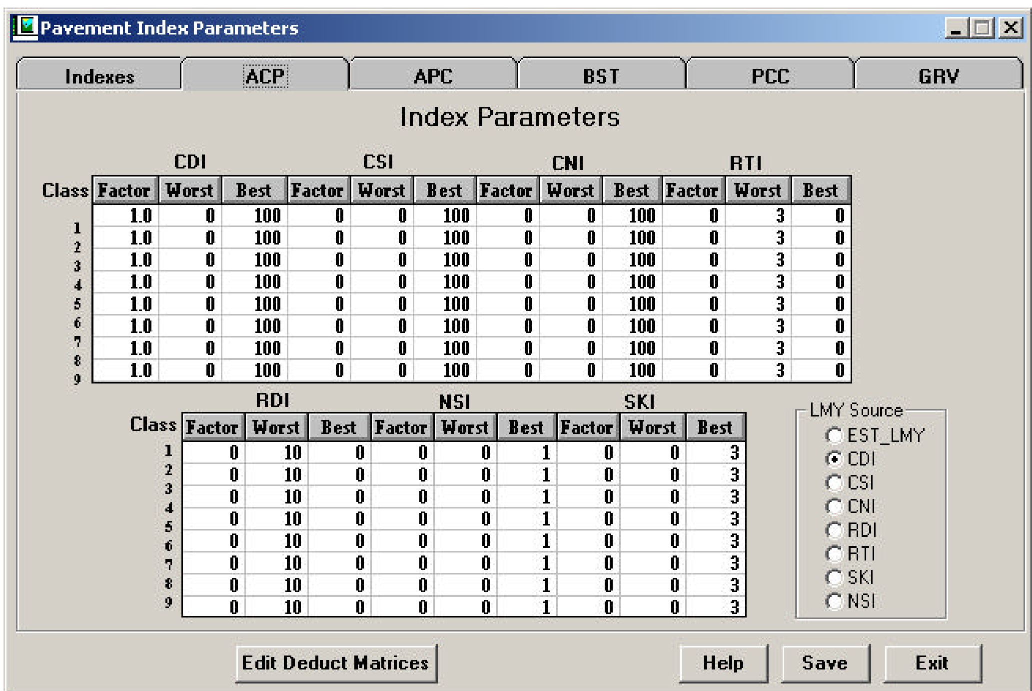


Figure 12. Multiple Index Definition Form

References:

1. Pavement Maintenance Management for Roads and Parking Lots, U.S. Army Corps of Engineers, Technical Report M-294, October 1981
2. Original WSDOT PMS report – WA-RD 50.1???
3. Pavement Management System for Washington State Cities and Counties, Washington State Transportation Center Report, July, 1986.
4. WSDOT – WA-RD 274.1
5. Computerized Pavement Condition Survey Unit, WA-RD 77.2
6. NWPMS Users Group Raters Manual #1
7. NWPMA Raters Manual #2
8. ASTM standards for roads and parking lot pavements (D6433-99)
9. StreetWise Manual, 1996

Appendix A

Deduct Curve Development

Procedure for Developing Deduct Curves

The WSC2 method outlined in this manual is presented as a starting point for the development of a statewide recommended or standardized rating system for Washington State Local Agency use. As discussed, this system was developed by the local agencies themselves. However, further work may need to be done on developing deduct curves that better fit Washington Local Agency use. Procedures and recommendations for the development of these deduct curves and score calculations are presented here. The curves and deduct matrix values currently in use and presented in this proposed standard may be sufficient and may be used as is. However, some new curves and possible changes to existing curves are being recommended. If there are to be changes to the existing deduct curves, current score values in use by various agencies could change. This may present problems and would need to be considered or addressed. Also, the Q-Curves may need to be modified as a result of current or possible future changes to the deduct curves.

You may want to consider separate curves for City, County, small or large agencies and Urban and/or Rural networks or sub-networks. Procedures or options should also be provided to allow each agency to modify the system to meet their needs. If a single standard index, (set of curves), is defined and required to be computed for statewide use/comparisons, it makes no difference or should be of no concern as to how or what other indices are in use or how they are being used.

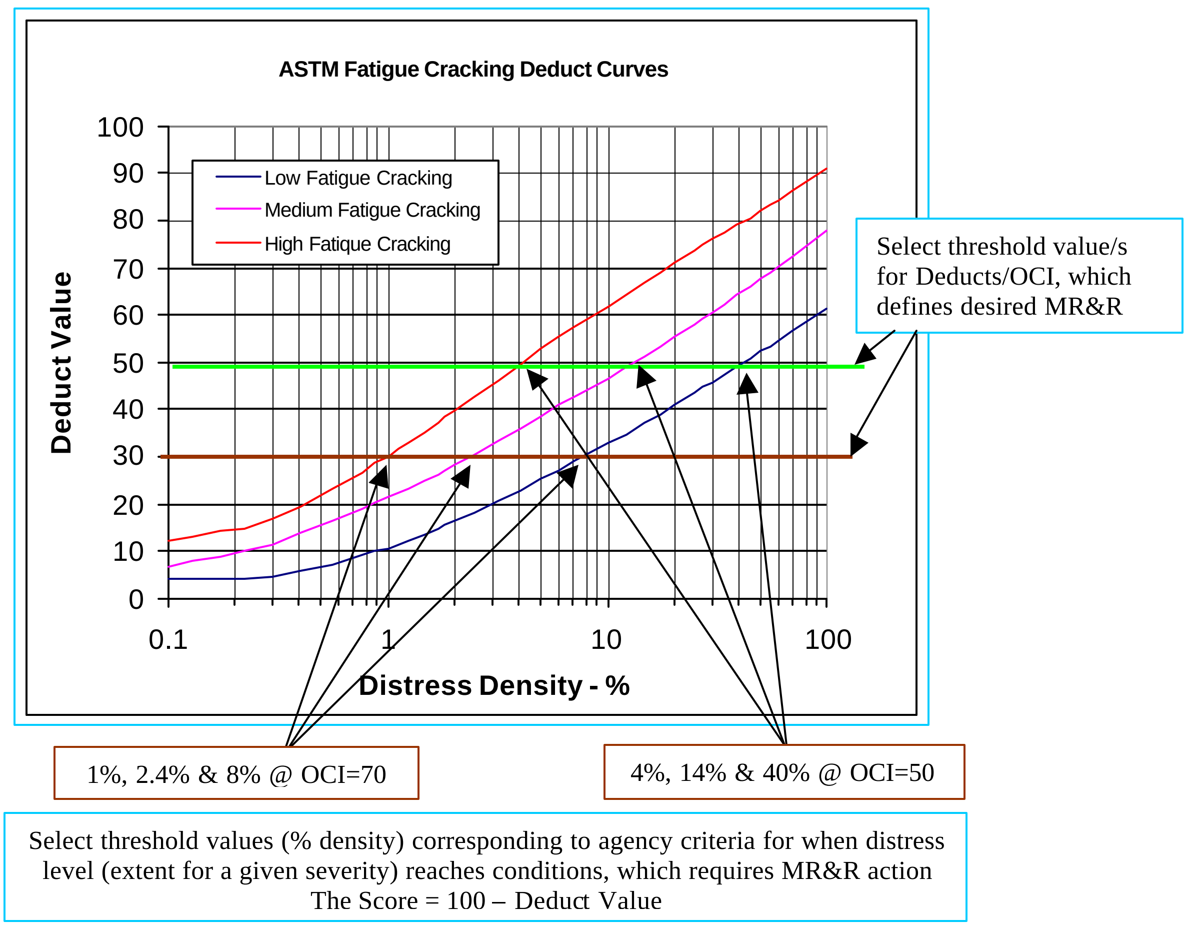


Figure A1 - Deduct trigger values for Fatigue Cracking

The above figure outlines a process for developing deduct curves and also helps to better understand the use and interpretation of these curves. The idea here is that for each distress type, one or more threshold value/s are set and corresponding density values for the low, medium and high severity levels are established. Then the deduct curves are created by drawing lines through these points with all lines beginning at or near the zero extent and zero deduct point.

A hypothetical example for fatigue cracking might be: Set your first deduct threshold at 50 points and lets say this is where you want to define the need for a rehabilitation overlay. For the low severity, you decide to define this point to happen at an extent of 40%, for medium severity the extent will be 14% and high severity will be 4%. See the above figure A1 & A2 for how this looks. In this case we have also defined a second threshold level at a deduct value of 30, for extent ranges of 8, 2.4 & 1. You may wish to define this as the threshold where you wish to apply routine or preventative maintenance. All existing deduct curves need to be looked at using this same process to see if they meet your current needs. See Figure A2, which summarizes this information for the current deduct curves.

What is recommended here is to start with the ASTM curves and look at the possibility of modifying these to better meet local use. It is also recommended that an option be provided to allow for the use of a matrix approach for collecting data on raveling and flushing (if the proposed unit conversion feature is included, this option would also be included). This is based on two arguments. First, there is not much you can do but apply a seal coat, overlay or reconstruct a roadway to address these defects. Therefore, detailed area type measurements do not fit the desired rehabilitation and are not necessary. Also, raveling is an extremely difficult distress to observe and measure accurately and consistently. It is by far the hardest distress to train raters to quantify in a consistent and repeatable manner.

The above procedure and the table in Figure A2 could be used as a starting point for the development of new deduct curves. It also provides a clear documentation of the existing WSC2/ASTM deduct curves. The recommended score calculation procedures/algorithm should follow the ASTM standards for roads and parking lot pavements (D6433-99) even though the curves are to be modified. It should be noted that 100% or at least full single lane sampling should be used and not the 10% sampling allowed for in this standard.

An expanded blank version of Figure A2 is provided in Figure A3 for the committee members (and to all agencies), which is to be filled out and a statistical analysis should be made of the results to come up with a final recommendation for new deduct curves. This Figure summarizes the procedure outlined in the Figures A1 & A2 for each distress type and severity. Just ask yourself, given the "Deduct Trigger Points" at what distress density (extent) would I (or do I currently) perform a given MR&R action to repair or preserve this pavement. Detailed discussion and interactive interaction on filling out this table should be performed at our next committee meeting and deduct curves should be developed from this interaction and test analysis should be done to evaluate the results of both the agreed to curves and the extreme upper and lower limits discussed by the group. I would be willing to do this analysis or at least assist in the performance and evaluation of the analysis and results. The Q-Curve correction procedure would also have to be evaluated as to its effect on changes in current deduct curves.

#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts Low	Med	High	Extent Limits Low Limit	High Limit	Deduct Source	Comments
1	Rutting/Waves ^	100	50	66	90	0.1	100	ASTM #15	Assume 100% extent
		-	25	45	60			WSDOT	PCR_2
2	Alligator/Fatigue Cracking	50	40	14	4	0.1	100	ASTM #1	
		30	8	2.4	1			“	
3	Longitudinal Fatigue Crks ^	30	8	8	8	0.1	100	ASTM #1 low	Convert to area & add to low AC
4	Longitudinal Non-Fatigue	30	30	9.5	2.4	0.2	30	ASTM #10	
5	Transverse Cracking	30	30	9.5	2.4	0.2	30	ASTM #10	
6	Raveling	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
7	Flushing	-	-	-	-	-	-	WSDOT	Use PCR_2 matrix approach
8	Maintenance Patching	30	40	9	3	0.1	50	ASTM #11	
9	Utility Patching ^	-	-	-	-	-	-	No deducts	Measure distress only
10	Corrugation & Waves	30	40	4.5	0.6	0.1	100	ASTM #5	
11	Sags & Humps	30	6.4	1.6	0.21	0.1	10	ASTM #4	
12	Block Cracking	20	15	40	5	0.1	100	ASTM #3	
13	Edge Condition	10	9	1.4	0.3	0.1	20	ASTM #7	
14	Crack Sealing	-	-	-	-	-	-	N/A	Inventory item only
15	Ride Quality	30	-	-	-	-	-	N/A	0-5 subjective guess?
16	Drainage	30	-	-	-	-	-	N/A	Open or closed, good or bad?

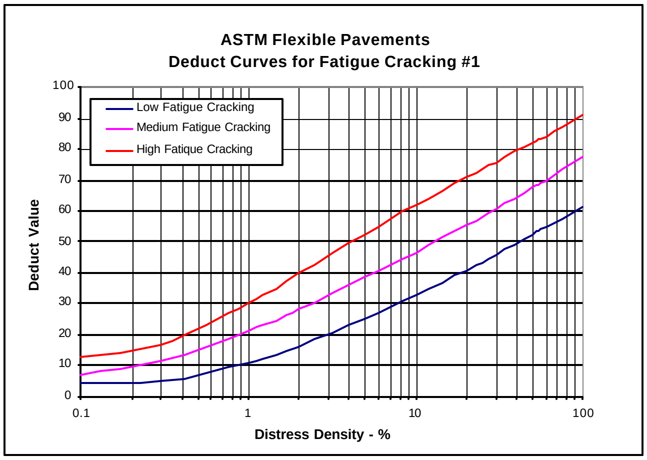
- * Values given here for trigger and % extent are taken from the ASTM curves
- ^ Does not have unique deduct curves – new curve may be needed or desired

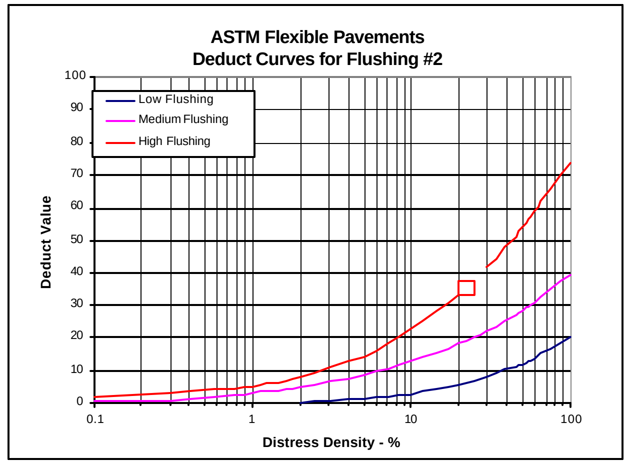
Note: Rigid or PCC pavements should stay as specified in Figure 7 or the ASTM system could be used directly.

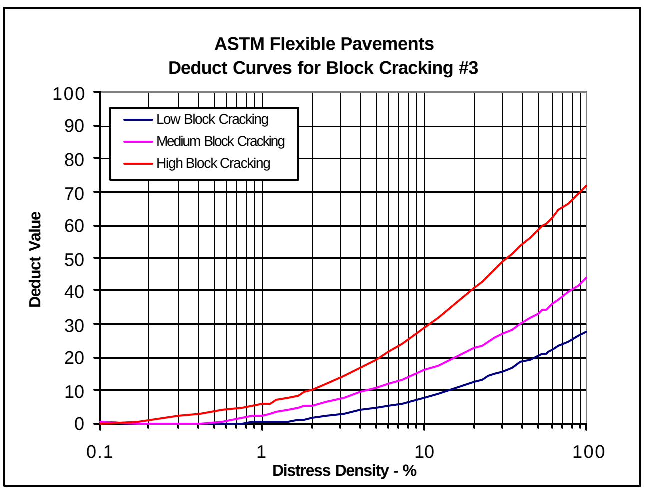
Figure A2. Deduct trigger values and deduct severity points for all distresses

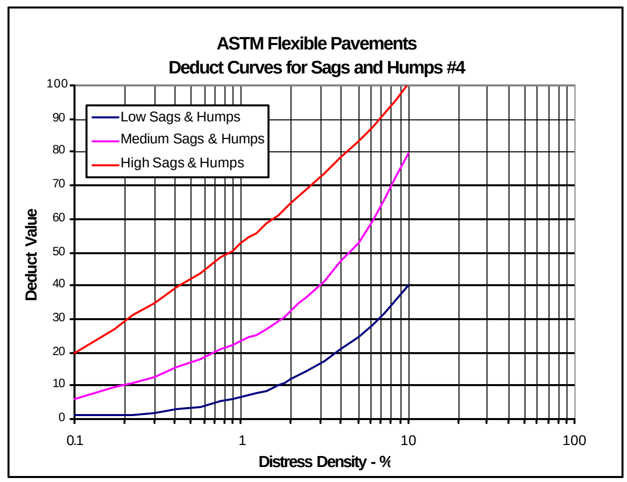
#	Flexible Distresses	Deduct Threshold Pts*	% Extent value for Each Severity Level @ Deduct Trigger Pts			Extent Limits		MR&R	Your Actions
			Low	Med	High	Low Limit	High Limit	Type	
1	Rutting/Waves ^							Reconstruct	
								Overlay	
								Maintenance	
2	Alligator/Fatigue Cracking							Reconstruct	
								Overlay	
								Maintenance	
3	Longitudinal Fatigue Crks ^							Reconstruct	
								Overlay	
								Maintenance	
4	Longitudinal Non-Fatigue							Reconstruct	
								Overlay	
								Maintenance	
5	Transverse Cracking							Reconstruct	
								Overlay	
								Maintenance	
6	Raveling							Reconstruct	
								Overlay	
								Maintenance	
7	Flushing							Reconstruct	
								Overlay	
								Maintenance	
8	Maintenance Patching							Reconstruct	
								Overlay	
								Maintenance	
9	Utility Patching ^							Reconstruct	
								Overlay	
								Maintenance	
10	Corrugation & Waves							Reconstruct	
								Overlay	
								Maintenance	
11	Sags & Humps							Reconstruct	
								Overlay	
								Maintenance	
12	Block Cracking							Reconstruct	
								Overlay	
								Maintenance	
13	Edge Condition							Reconstruct	
								Overlay	
								Maintenance	
14	Crack Sealing							Reconstruct	
								Overlay	
								Maintenance	
15	Ride Quality							Reconstruct	
								Overlay	
								Maintenance	
16	Drainage							Reconstruct	
								Overlay	
								Maintenance	

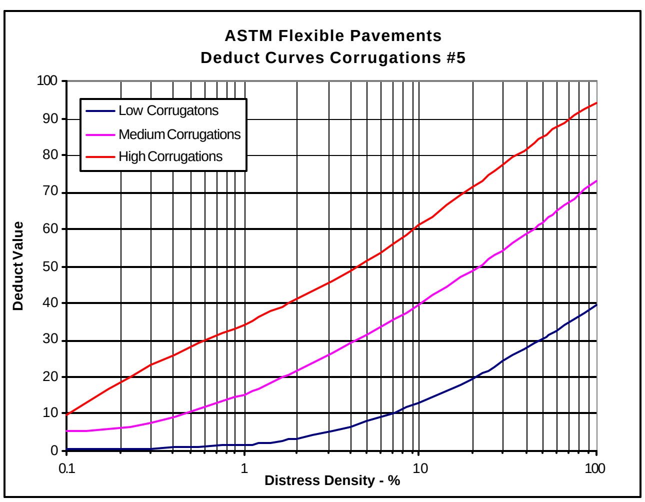
Figure A3. Blank form for setting new trigger points and corresponding severity level points

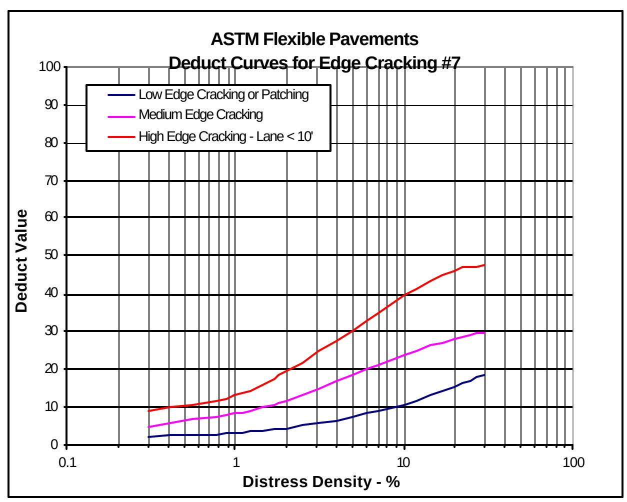

ASTM Flexible Pavements
Deduct Curves for Fatigue Cracking #1
Low Fatigue Cracking
Medium Fatigue Cracking
High Fatigue Cracking
Deduct Value
Distress Density - %

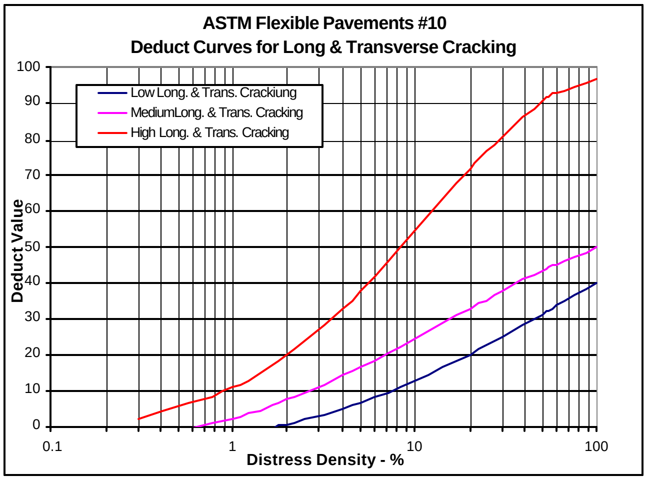

ASTM Flexible Pavements
Deduct Curves for Flushing #2
Low Flushing
Medium Flushing
High Flushing
Deduct Value
Distress Density - %

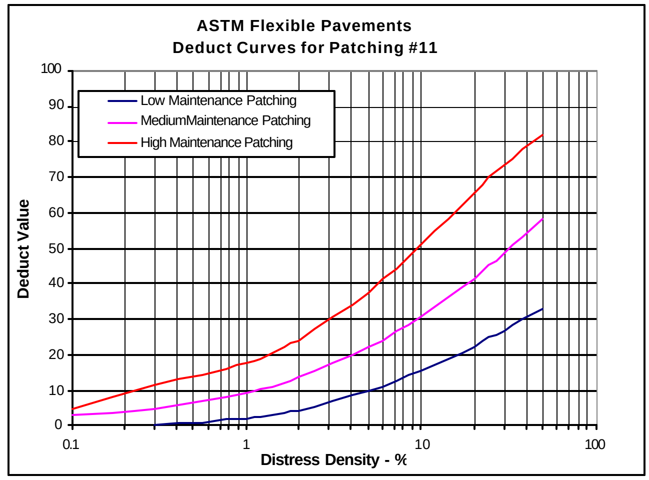

ASTM Flexible Pavements
Deduct Curves for Block Cracking #3
Low Block Cracking
Medium Block Cracking
High Block Cracking
Deduct Value
Distress Density - %

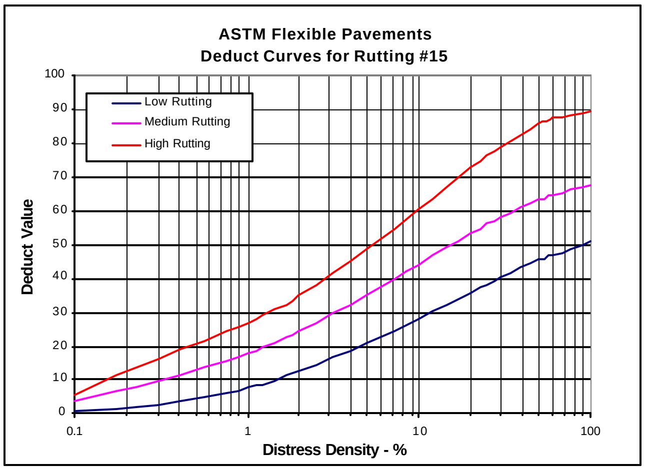

ASTM Flexible Pavements
Deduct Curves for Sags and Humps #4
Low Sags & Humps
Medium Sags & Humps
High Sags & Humps
Deduct Value

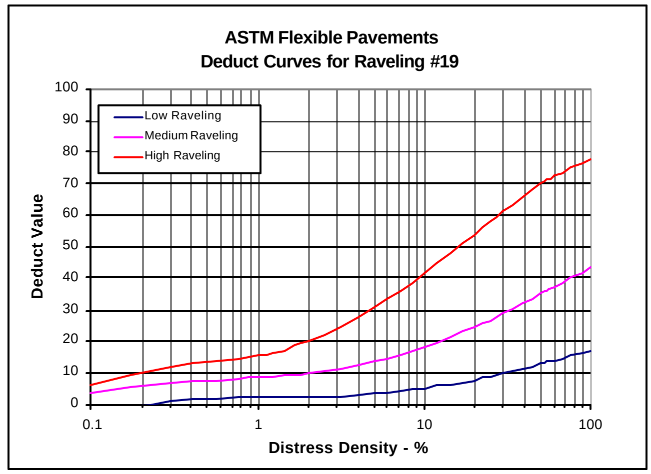

ASTM Flexible Pavements
Deduct Curves Corrugations #5
Low Corrugatons
Medium Corrugations
High Corrugations
Deduct Value
Distress Density - %


ASTM Flexible Pavements
Deduct Curves for Edge Cracking #7
Low Edge Cracking or Patching
Medium Edge Cracking
High Edge Cracking - Lane < 10'
Deduct Value
Distress Density - %



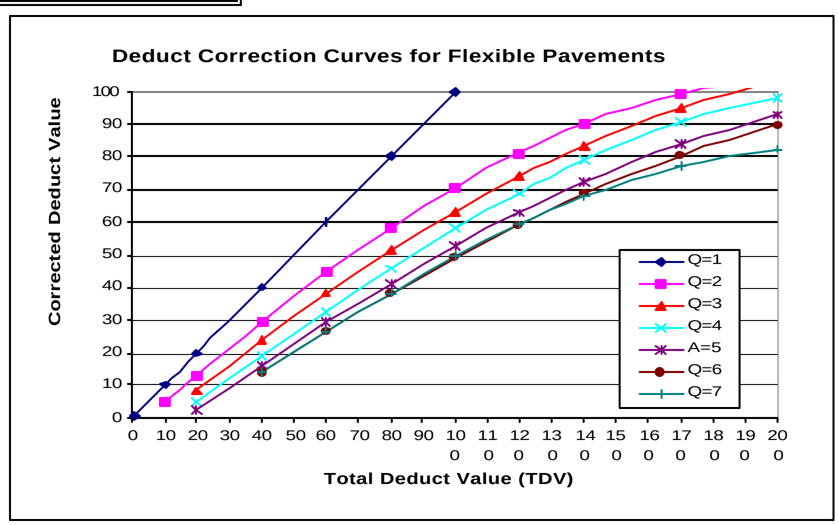


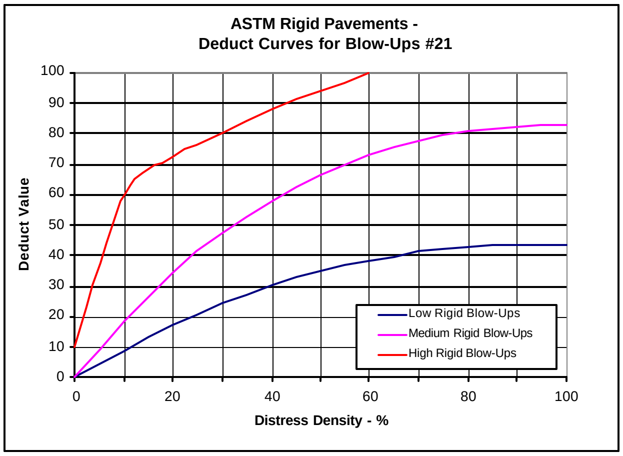


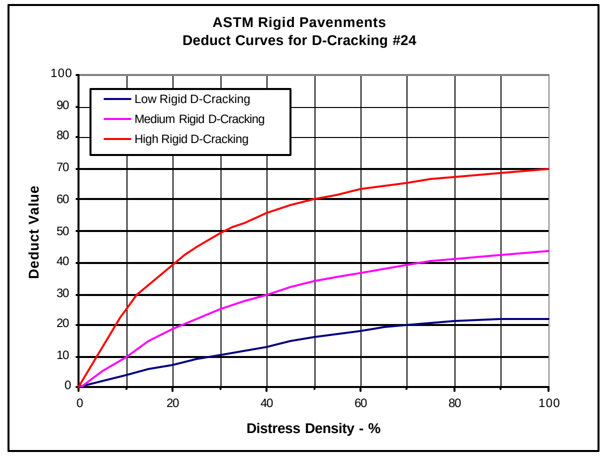


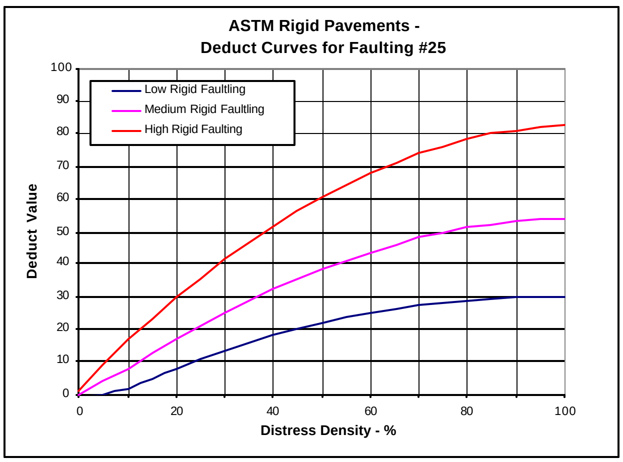
Extent Range	Raveling			Flushing		
	Low	Med	High	Low	Med	High
1	5	20	45	5	20	45
2	10	30	65	10	30	65
3	15	40	75	15	40	75

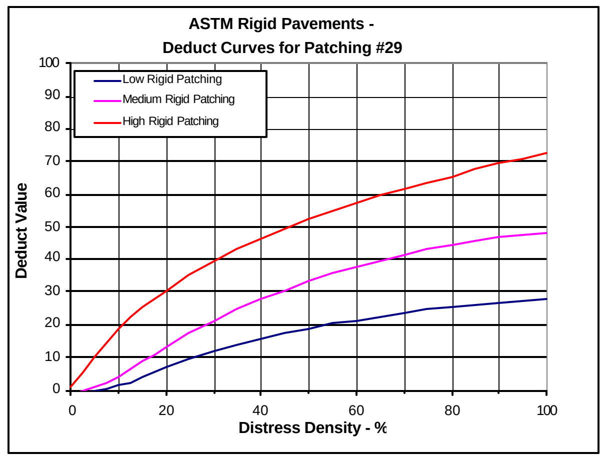
Extent Range	Rutting		
	Low	Med	High
100%	25	45	60

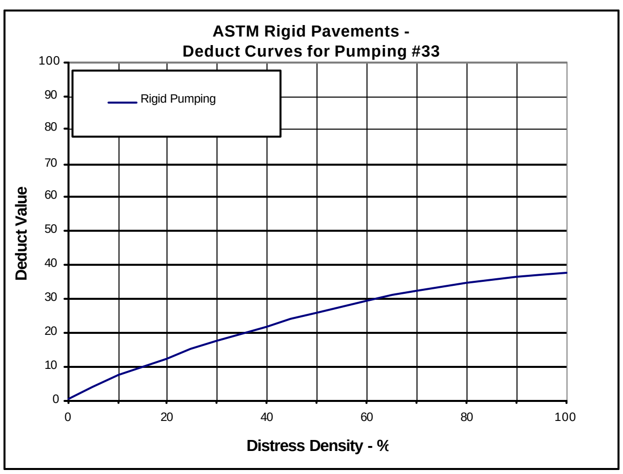


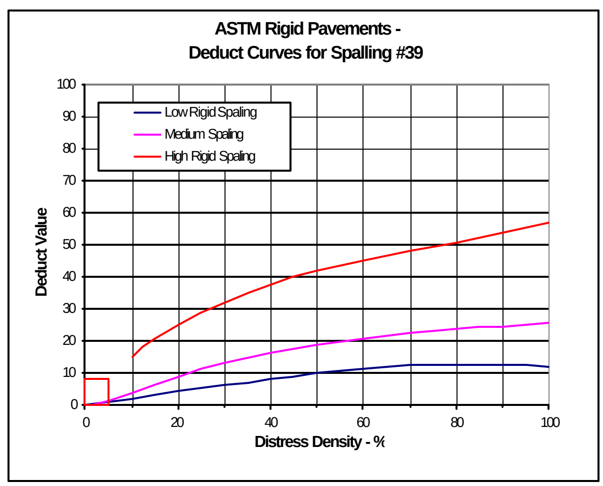

ASTM Rigid Pavements -
Deduct Curves for Blow-Ups #21
Deduct Value
Distress Density - %
Low Rigid Blow-Ups
Medium Rigid Blow-Ups
High Rigid Blow-Ups

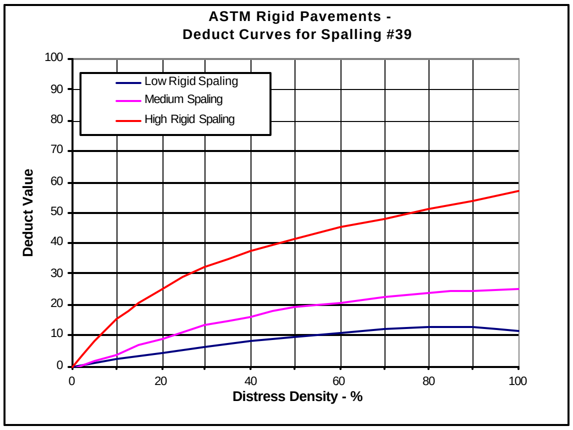

ASTM Rigid Pavenments
Deduct Curves for D-Cracking #24
Deduct Value
Distress Density - %
Low Rigid D-Cracking
Medium Rigid D-Cracking
High Rigid D-Cracking


ASTM Rigid Pavements -
Deduct Curves for Faulting #25
Deduct Value
Distress Density - %
Low Rigid Faultling
Medium Rigid Faultling
High Rigid Faulting


ASTM Rigid Pavements -
Deduct Curves for Patching #29
Deduct Value
Distress Density - %
Low Rigid Patching
Medium Rigid Patching
High Rigid Patching


ASTM Rigid Pavements -
Deduct Curves for Pumping #33
Deduct Value
Distress Density - %
Rigid Pumping


ASTM Rigid Pavements -
Deduct Curves for Spalling #39
Deduct Value
Distress Density - %
Low Rigid Spaling
Medium Spaling
High Rigid Spaling



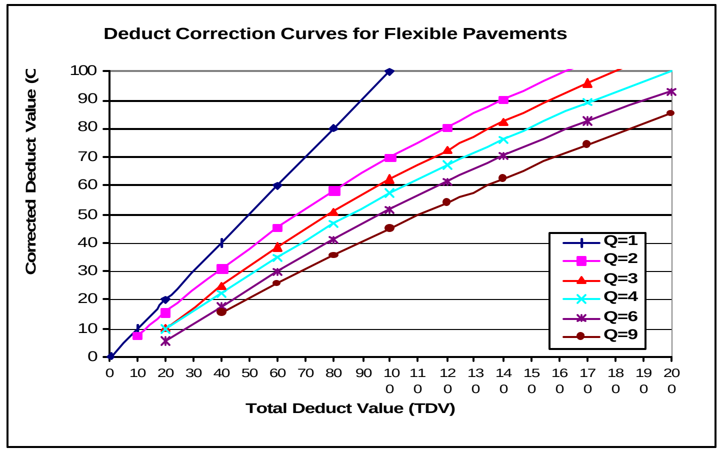


Figure A4 - ASTM Deduct curves and WSDOT matrix values used the WSC2 algorithm

The plots in Figure A4 are of the deduct curves and Q-Curves currently used in the WSC2 method.

Deduct Equations

The following figure (Figure A5) contains the coefficients for the fourth order polynomial equations used to represent the deduct curves shown in Figure A4. The independent variable for the flexible equations is the log to the base 10 of "D" and for the rigid equations is the square root of "D". This includes the Q-Curve equations. The general form of the polynomial equation is:

$$\text{Deduct Value} = a_0 + a_1{*}D + a_2{*}D^2 + a_3{*}D^3 + a_4{*}D^4$$

Where a_i = the polynomial coefficients
D = Distress Density

These coefficients and their implementation should be built into the software. Careful investigation of the individual plots showing the deduct curves shows that there are also upper and lower cutoff values that must be included in any algorithm used in the calculation of a final score value.

Distress Type	Distress Code	Fourth Order Polynomial Coeficients				
		a0	a1	a2	a3	a4
FLEXIBLE PAVEMENTS						
Fatigue Cracking	1L	10.76631	16.06206	7.437122	-1.729531	0.1656121
	1M	21.20758	22.07689	4.98997	-2.21639	0.6349416
	1H	30.09477	30.36745	5.640016	-5.571499	1.387932
Bleeding/ Flushing	2L	0.06117674	0.541575	0.8662004	0.8498797	0.5313094
	2M	3.032452	5.700002	3.093747	0.4240029	0.5737981
	2H	5.17904	6.680578	7.204208	3.658565	-0.174863
Blocking Cracking	3L	0.3178311	2.748062	3.969231	1.14345	-0.2056097
	3M	2.44066	8.346344	5.276794	-0.4388349	0.4466787
	3H	5.810543	10.97477	10.37727	3.758215	-1.719811
Bumps & Sags	4L	6.56634	13.7332	11.45712	6.019511	2.69289
	4M	23.33472	24.85903	13.5691	11.84113	6.000502
	4H	52.55737	36.80389	6.978104	3.322715	0.5491591
Corrugation	5L	1.512638	4.115602	5.924517	2.195815	-0.7209934
	5M	15.24676	19.18126	6.663609	-1.927099	0.5124799
	5H	34.13027	21.33617	2.967594	4.312834	-1.801965
Edge Cracking	7L	3.098869	2.741005	3.331008	2.826385	-1.114229
	7M	8.102079	9.87385	7.699901	0.06718894	-2.070882
	7H	13.10491	15.46303	15.55702	0.7275021	-5.195654
Jt. Reflection Cracking	8L	2.333196	6.324641	4.187891	0.7108985	0.5417839
	8M	6.903778	13.66543	15.94607	2.80448	-5.82797
	8H	14.32657	24.51447	29.02969	5.417187	-12.35227
Long & Trans Cracking	10L	-2	7.128434	7.144287	1.232346	-0.6564663
	10M	2.434791	15.19253	7.697273	0.2361945	-0.9836057
	10H	10.73561	24.606812	19.38489	4.409818	-4.743978
Patching – Maint & Util	11L	2.018603	6.267308	6.380386	1.519005	-0.6735938
	11M	9.178881	12.31777	8.063919	1.595175	-0.3636719
	11H	17.59592	16.64061	14.78329	6.381207	-4.555707
Rutting	15L	7.740014	13.98259	7.613645	-0.319505	-0.7703743
	15M	17.75414	19.8763	7.830004	0.4110756	-1.541423
	15H	26.84874	23.21115	9.698143	4.229975	-3.521132
RIGID PAVEMENTS						
Blow-Ups, Buckling	21L	1.075885	-2.277335	1.910797	-0.1387815	0.001315707
	21M	0.5334379	-2.808092	3.485365	-0.2817362	0.00435862
	21H	6.84159E-05	33.15005	-6.568157	0.7625287	-0.03265801
Durability "D" Cracking	24L	-0.004010735	0.8763244	-0.04147666	0.0718426	-0.005455566
	24M	-0.005132361	-1.755567	2.264117	-0.2491581	0.00839356
	24H	-0.02026826	-0.1827656	4.103357	-0.5683063	0.02301004
Faulting	25L	0.05048959	-3.924944	1.758336	-0.1116751	0.000466876
	25M	0.2886105	-0.9700167	1.078249	0.02104242	-0.006534028
	25H	0.02812832	1.786676	0.9869397	0.06831125	-0.01022781
Patching – Maint & Util	29L	0.01141115	-4.801229	2.28532	-0.2251096	0.007252104
	29M	0.05491786	-5.266649	2.739694	-0.2245205	0.005135919
	29H	0.00127549	1.000432	2.257623	-0.2583954	0.009506822

Pumping	33L	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
	33M	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
	33H	-0.007033201	1.297081	0.131167	0.07180289	-0.006017558
Scaling/Map.Cracking/Crazing	36L	-0.005498127	0.5250595	0.03453166	0.02543511	-0.002311515
	36M	-0.004765573	1.558811	0.7013905	-0.08564021	0.003049744
	36H	0.002616919	2.980689	1.563296	-0.2294174	0.01080361
Spalling, U Joint	39L	0.005293494	0.4996557	-0.1738746	0.08619857	-0.006190385
	39M	0.01631164	-2.499113	1.626158	-0.1611324	0.004882555
	39H	-0.007345416	-0.6621614	2.684679	-0.3531971	0.01480706
Flexible Pavement Q-Curves		0	1	0	0	0
		-3.751461	0.867283	-0.000792269	-4.3358E-06	0
		-8.753528	0.8771629	-0.001540591	-1.6656E-07	0
		-9.518578	0.7212437	-7.18709E-06	-4.54624E-06	0
		-11.98916	0.7334721	-0.000701202	-1.70044E-06	0
		-12.69505	0.6966763	-0.000655683	-1.29781E-06	0
		-11.85087	0.644604	0.000209163	-5.39841E-06	0
Rigid Pavement Q-Curves		0	1	0	0	0
		-2.653785	0.7087711	0.8067448	-0.005579318	-0.0009852
		-0.06883989	-3.679021	1.702055	-0.08988975	0.001865475
		20.50162	-12.31248	2.888301	-0.1636908	0.003487131
		-0.5285331	-3.047427	1.113089	-0.0245154	-0.000417592
		-8.645523	1.71922	0.1775138	0.03404739	-0.001558422

Figure A5. Equation Coefficients for the ASTM Deduct Curves.

Appendix B

ASTM Q-Curve Procedures

ASTM Q-Curve Algorithm

The following text, figures and related procedure was taken directly from the ASTM standard for the rating of roadway pavements.

9. Calculation of PCI for Asphalt Concrete (AC) Pavement

9.1 Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities" section. For example, Figure 4 shows five entries for the Distress Type 1, Alligator Cracking": 5L, 4L, 4L, 8H, and 6H. The distress at each severity level is summed and entered in the 'Total Severity" section as 13 ft^2 (1.2 m^2) of low severity and 14 ft^2 (1.3 m^2) of medium severity. The units for the quantities may be either in square feet (square meters), linear feet (meters), or number of occurrences, depending on the distress type.

9.2 Divide the total quantity of each distress type at each severity level from 9.1 by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

9.3 Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix A.

9.4 Determine the maximum corrected deduct value (CDV). The procedure for determining maximum CDV from individual DVs is identical for both AC and PCC pavement types.

9.5 The following procedure must be used to determine the maximum CDV.

9.5.1 If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; otherwise, maximum CDV must be determined using the procedure described in 9.52-9.5.5.

9.5.2 List the individual deduct values in descending order. For example, in Figure 6 this will be 25.1, 23.4, 17.9, 11.2,7.9, 7.5, 6.9, and 5.3.

9.5.3 Determine the allowable number of deducts, m, from Figure 5, or using the following formula (see Eq 4):

$$m = I + (9/98)(100-HDV) <= 10 \qquad (4)$$

where:

m = allowable number of deducts including fractions (must be less than or equal to ten), and

HDV = highest individual deduct value.
(For the example in Figure 4, m = I + (9/98)(100-25.1) = 7.9).

9.5.4 The number of individual deduct values is reduced to the m largest deduct values, including the fractional part. For the example in Figure 6, the values are 25.1, 23.4, 17.9, 11.2,7.9, 7.5, 6.9, and 4.8 (the 4.8 is obtained by multiplying 5.3 by (7.9 -7 = 0.9»). If less than III deduct values are available, all of the deduct values are used.

9.5.5 Determine maximum CDV iteratively, as shown in Figure6.

9.5.5.1 Determine total deduct value by summing individual deduct values. The total deduct value is obtained by adding the individual deduct values in 9.5.4, that is, 104.7.

9.5.5.2 Determine *q* as the number of deducts with a value greater than 2.0. For example, in Figure 6, *q=8*.

9.5.5.3 Determine the CDV from total deduct value and *q* by looking up the appropriate correction curve for AC pavements in Appendix A.

9.5.5.4 Reduce the smallest individual deduct value greater than 2.0 to 2.0 and repeat 9.5.5.1-9.5.5.3 until q=1.

9.5.5.5 Maximum CDV is the largest of the CDVs.

9.6 Calculate PCI by subtracting the maximum CDV from 100: PCI = lOO-max CDV.

9.7 Figure 6 shows a summary of PCI calculation for the example AC pavement data in Figure 4. A blank PCI calculation form is included in Figure 2.

10. Calculation of PCI for Portland Cement Concrete (PCC) Pavement

10.1 For each unique combination of distress type and severity level. Add up the total number of slabs in which they occur. For the example, in Figure 7. there are two slabs containing low-severity corner break (Distress 22L).

10.2 Divide the number of slabs from 10.1 by the total number of slabs in the sample unit and multiply by 100 to obtain the percent density of each distress type and severity combination.

10.3 Determine the deduct values for each distress type severity level combination using the corresponding deduct curve in Appendix A.

10.4 Determine PCI by following the procedures in 9.5 and 9.6, using the correction curve for PCC pavements (see Appendix A*)* in place of the correction curve for AC pavements.

10.5 Figure 7 shows a summary of PCI calculation for the example PCC pavement distress data in Figure 8.

11. Determination of Section PCI

II.1 If all surveyed sample units are selected randomly or if every sample unit is surveyed then the PCI of the section is the average of the PCls of the sample units. If additional sample units, as defined in 2.1.1. are surveyed then a weighted average is used as follows:

$$PCIs = (N - A)(PCI_R)/N + A(PCI_A)/N \quad (5)$$

Where:

PCI_s	=	weighted PC' of the section,
N	=	total number of sample units in the section,
A	=	number of additional sample units,
PCI_R	=	mean PCI of randomly selected sample units, and
PCI_A	=	mean PC' of additional selected sample units.

11.2 Determine the overall condition rating of the section by using the section PCI and the condition rating scale in Figure 10.

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

SKETCH:

BRANCH________ SECTION________ SAMPLE UNIT________
SURVEYED BY________ DATE________ SAMPLE AREA________

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE

Figure B2

CONCRETE SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

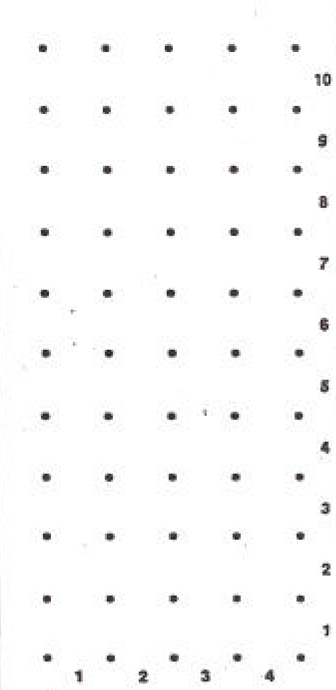
BRANCH________ SECTION________ SAMPLE UNIT________
SURVEYED BY________ DATE________ SAMPLE AREA________

Distress Types

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE

SKETCH:



ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SPRINGFIELD SECTION 001 SAMPLE UNIT 1
SURVEYED BY KAK DATE 10 Jul 93 SAMPLE AREA 2500 sf

SKETCH:

100'
25'
N
Direction of survey →

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE
1L	1x5	1x4	1x4							13	0.52	7.9
1H	1x8	1x6								14	0.56	23.4
7L	32	15	18	24	41					130	5.20	7.5
8M	20	15	35	27	23	10	13			143	5.72	25.1
11H	3x4	2x5								22	0.88	17.9
13L	1									1	0.04	11.2
15L	4	9	8							21	0.84	6.9
19L	250									250	10.0	5.3

FIG. 4 Example of a Flexible Pavement Condition Survey Data Sheet

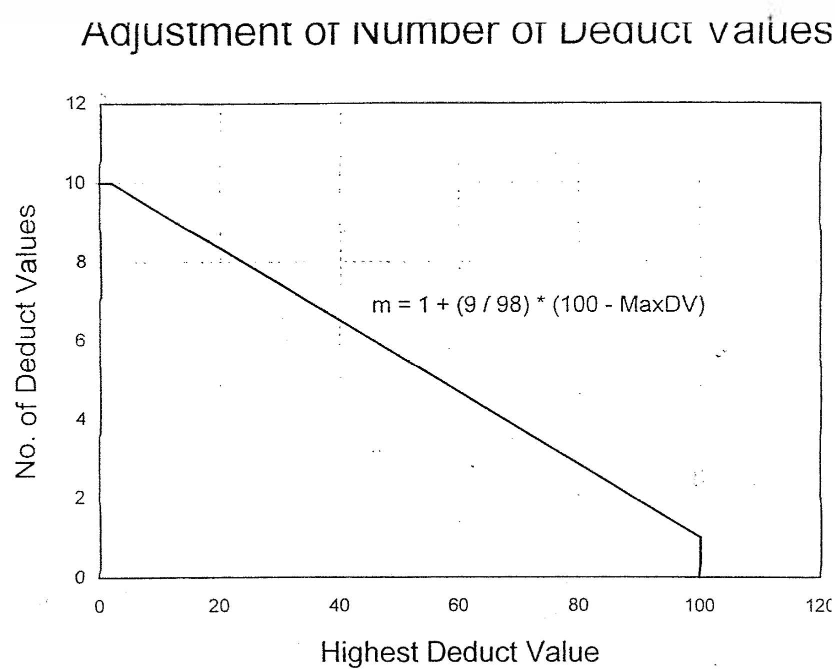


FIG. 5 Adjustment of Number of Deduct Values

m = 1 + (9/98) (100 - 25.1) = 7.9 < 8

Use highest 7 deducts and 0.9 of eighth deduct.

0.9 x 5.3 = 4.8

#	Deduct Values										Total	q	CDV
1	25.1	23.4	17.9	11.2	7.9	7.5	6.9	4.8			104.7	8	51.0
2	25.1	23.4	17.9	11.2	7.9	7.5	6.9	2			101.9	7	50.0
3	25.1	23.4	17.9	11.2	7.9	7.5	2	2			96.0	6	46.0
4	25.1	23.4	17.9	11.2	7.9	2	2	2			90.5	5	47.0
5	25.1	23.4	17.9	11.2	2	2	2	2			84.6	4	48.0
6	25.1	23.4	17.9	2	2	2	2	2			75.4	3	48.0
7	25.1	23.4	2	2	2	2	2	2			59.5	2	44.0
8	25.1	2	2	2	2	2	2	2			38.1	1	38.0
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 6 Calculation of Corrected PCI Value—Flexible Pavement

Type #'s should be Corrected - see Fig 3

FIG 7

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SECOND SECTION 001 SAMPLE UNIT 1
SURVEYED BY KTJ DATE 10 Jul 93 SAMPLE AREA 20 slabs

Distress Types

1. Blow up/Buckling
2. Corner Break
3. Divided Slab
4. Durability Crack
5. Faulting
6. Joint Seal
7. Lane/Shoulder
8. Linear Cracking
9. Patching (Large)
10. Patching (Small)
11. Polished Aggregate
12. Popouts
13. Pumping
14. Punchout
15. Railroad Crossing
16. Scaling
17. Shrinkage
18. Spalling Corner
19. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
26	H	–	100	8.0
22	L	3	15	12.6
22	M	1	5	7.7
23	M	3	15	30.5
30	M	4	20	4.4
34	M	2	10	25.1
38	L	6	30	5.8
39	H	1	5	9.0

SKETCH: 20'x15' ea

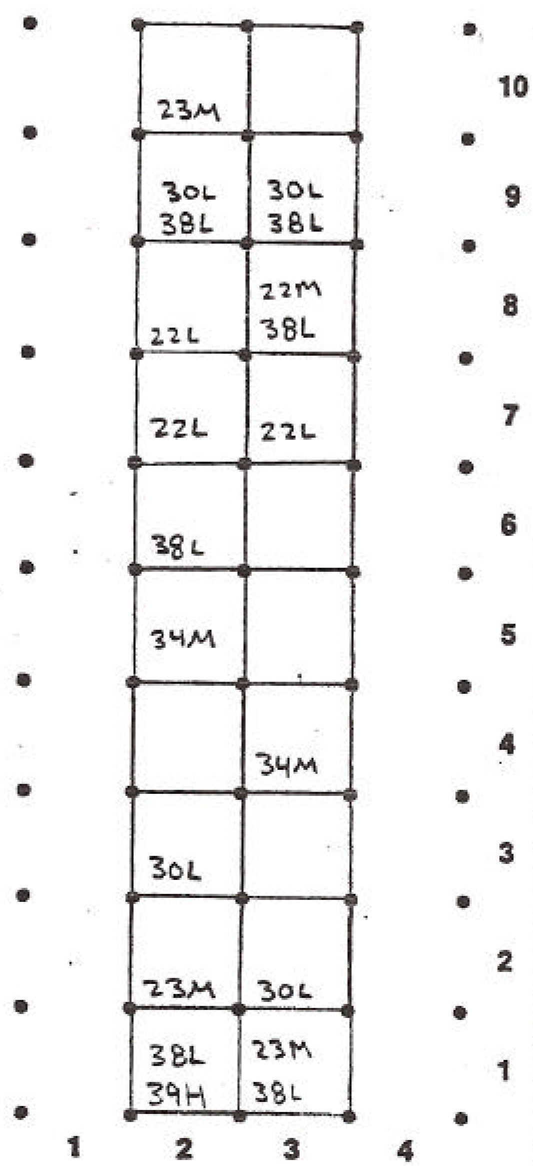


FIG 8

#	Deduct Values										Total	q	CDV	
1	30.5	25.1	12.6	9.0	8.0	7.7	5.8	1.76			100.5	7	50.0	
2	30.5	25.1	12.6	9.0	8.0	7.7	2	1.76			96.7	6	49.5	
3	30.5	25.1	12.6	9.0	8.0	2	2	1.76			91.0	5	51.0	*
4	30.5	25.1	12.6	9.0	2	2	2	1.76			85.0	4	49.0	
5	30.5	25.1	12.6	2	2	2	2	1.76			78.0	3	50.0	
6	30.5	25.1	2	2	2	2	2	1.76			67.4	2	50.0	
7	30.5	2	2	2	2	2	2	1.76			44.3	1	44.3	
8														
9														
10														

$m = 1 + 9/98\,(100 - DV_{max}) = 7.38 < 8$

$4.4 \times 0.4 = 1.76$

Max CDV = 51

PCI = 100 - Max CDV = 49

RATING = FAIR

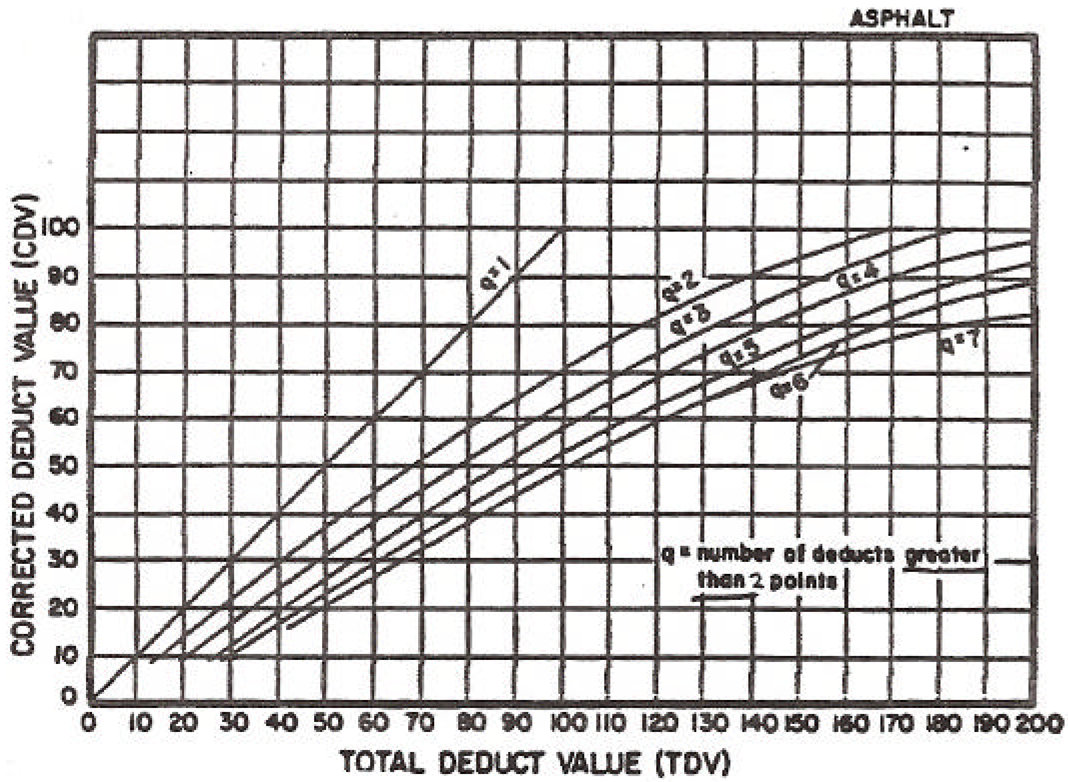


Figure B20. Corrected deduct value curves for asphalt-surfaced pavements.

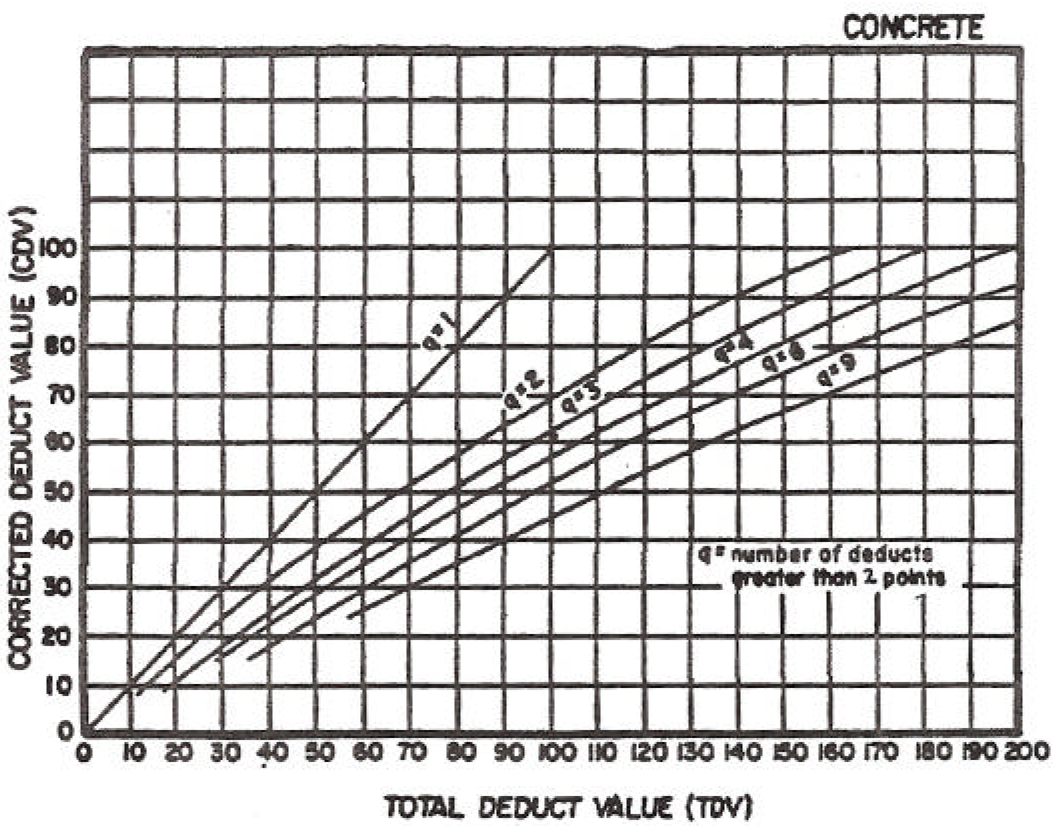


Figure Corrected deduct values for jointed concrete pavement.

Appendix C

Example Index Computation

(To be provided)

Appendix D

Index Comparisons

By
Derald Christensen

MEASUREMENT RESEARCH CORPORATION
4126 4th Street NW - Gig Harbor, WA 98335
(253) 851-3200 - FAX (253) 851-4334
e-mail mrc@harbornet.com

Comparison of PSC, $PCR_{1\&3}$, and WSC2/CSI Rating Methods

The following tables are provided to help the user see some of the differences between the PSC, PCR_1, PCR_3 and the WSC2 Combined Structural Index (CSI) values computed using the PAVER/ASTM deduct curves. These data where extracted from the WSDOT publication WR-RD 274.1 (September 1993) and these values represent the deduct values assigned to each distress severity and extent combination as measured and assigned based on the field data collection operations. These numbers are summed together and subtracted from 100 to compute the score. The PCR_3 was added to the original data provided by the above reference.

Figure D - Alligator Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/P CI	PCR_3	PSC	PCR_1	CDI/P CI	PCR_3	PSC	PCR_1	CDI/ PCI	PCR_3
1	6	20	6	7	10	35	15	14	16	50	22	21
12.5	31	20	27	38	45	35	41	52	56	50	56	68
37	65	25	40	54	84	40	54	68	96	55	70	83
62	92	45	46	54	100	45	62	68	100	60	76	83
75	100	50	49	54	100	50	64	68	100	65	79	83

Figure D2 - Patching Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/ PCI	PCR_3	PSC	PCR_1	CDI/P CI	PCR_3	PSC	PCR_1	CDI/ PCI	PCR_3
1	5	20	2	0	9	25	10	5	14	30	19	12
5	14	20	10	21	23	25	22	38	31	30	37	62
25	41	25	25	33	57	30	45	58	68	35	72	80

Figure D3 - Transverse Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/ PCI	PCR_3	PSC	PCR_1	CDI/P CI	PCR_3	PSC	PCR_1	CDI/ PCI	PCR_3
1	5	5	2	0	9	10	9	0	14	15	18	0
5	15	10	11	4	21	10	20	10	32	20	44	20
10	23	15	17	9	23	15	22	17	23	15	17	36

Figure D4 - Longitudinal Cracking Deduct Values

Extent	Low Severity				Medium Severity				High Severity			
%WP	PSC	PCR_1	CDI/ PCI	PCR_3	PSC	PCR_1	CDI/ PCI	PCR_3	PSC	PCR_1	CDI/ PCI	PCR_3
1	1	5	0	0	3	15	0	0	5	30	4	11
100	27	15	15	n/a	40	30	28	n/a	50	45	56	n/a
200	43	30	22	n/a	59	45	38	n/a	71	60	76	n/a

Note: The PCR_3 index was added to the data in the original WSDOT report, which is provided in these tables

PSC = the index computed from the WSDOT equations

PCR_1 = Original WSDOT windshield discrete matrix method

CSI/PCI = WSC2/ASTM method

PCR_3 = Streetwise method

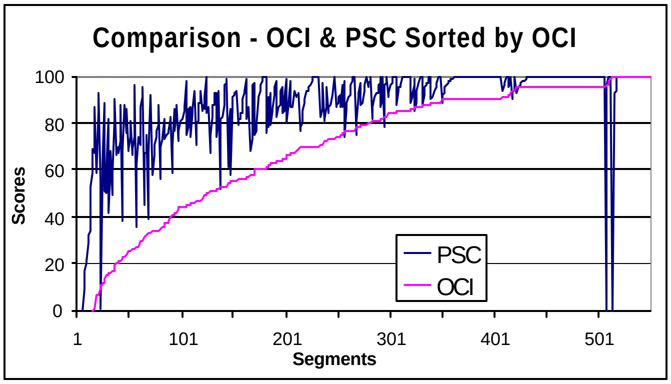


Figure D5 Comparison plot of OCI and PSC sorted by OCI

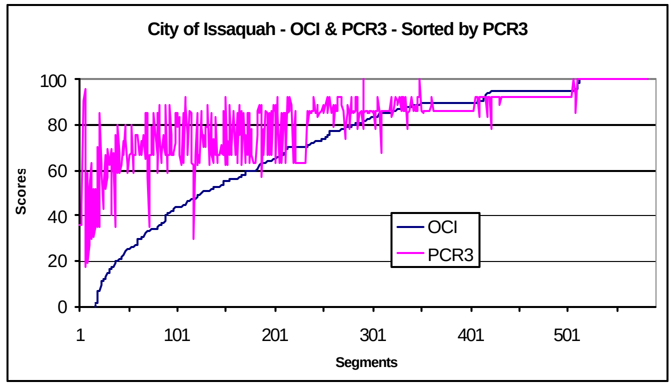


Figure D6 Comparison plot of OCI & PCR_3 sorted by OCI – (The above title is wrong.)

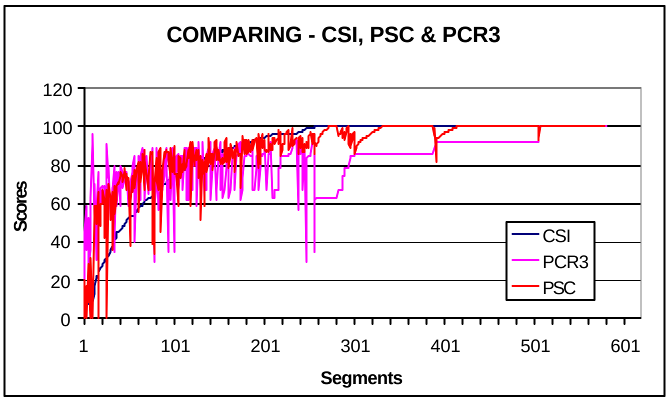


Figure D7 Plot of CSI, PSC & PCR_3 sorted by CSI

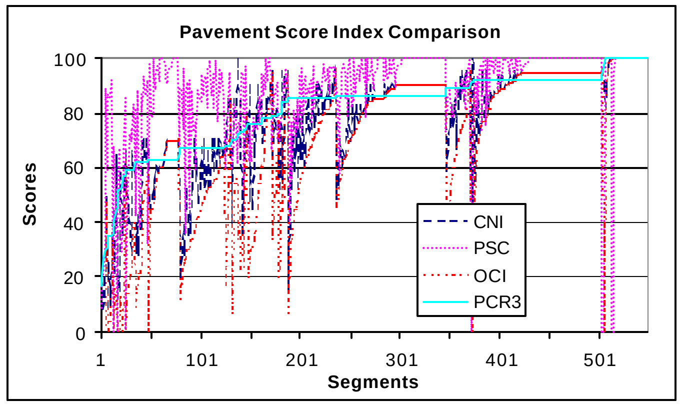


Figure D8 CSI, PSC, OCI & PCR_3 sorted by PCR_3 (the CNI above should be CSI)

Figure D9 System wide index score averages

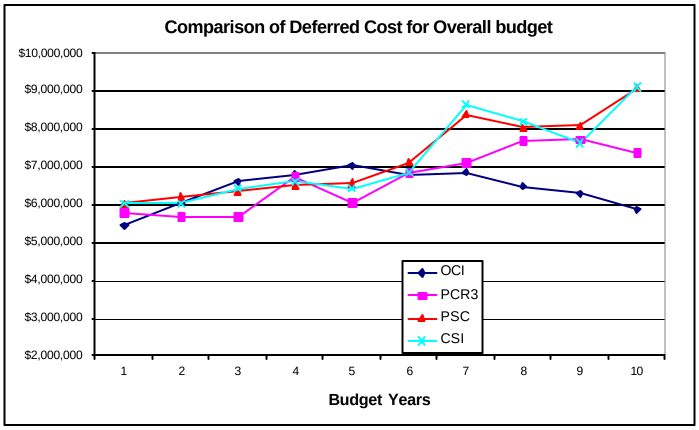
CLASS	OCI	CNI	CSI	PCR_3	PSC
1	47	73	65	80	62
2	53	75	72	80	70
3	63	76	80	80	79
4	73	86	83	88	82
ALL	67	82	80	85	78

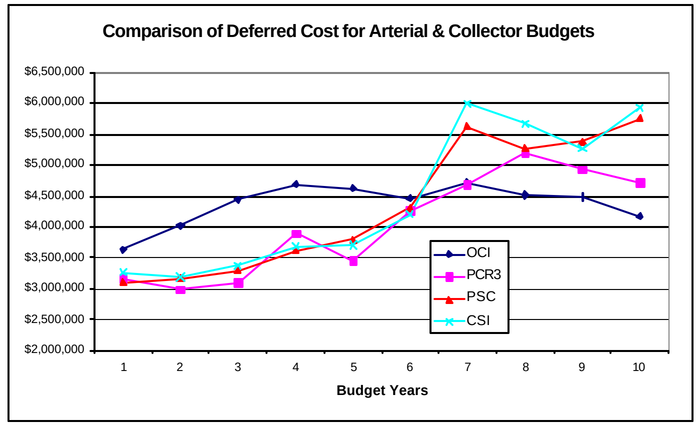
Figure D10 System wide index score averages normalized by the OCI

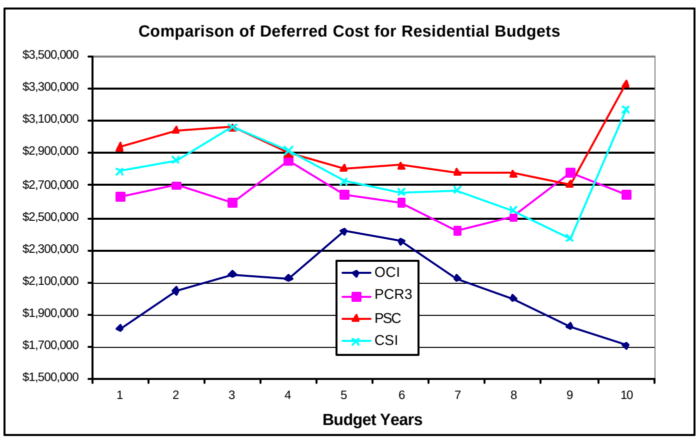
CLASS	OCI	CNI	CSI	PCR_3	PSC
1	1	1.6	1.4	1.7	1.3
2	1	1.4	1.4	1.5	1.3
3	1	1.2	1.3	1.3	1.3
4	1	1.2	1.1	1.2	1.1
ALL	1	1.2	1.2	1.3	1.2

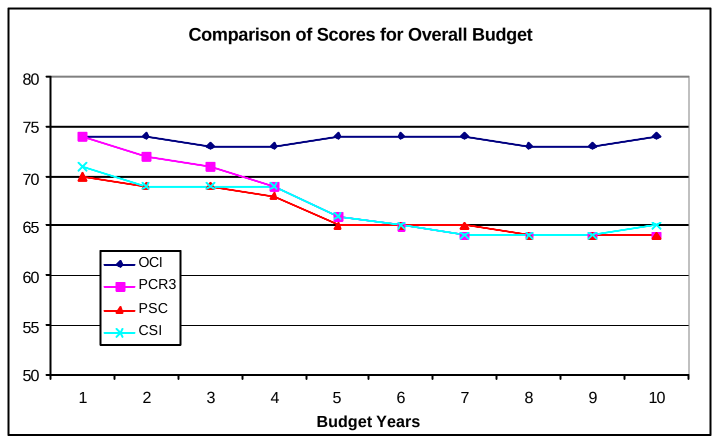
Figure D11 Comparison based on 10-year network analysis for a total annual budget of $650,000

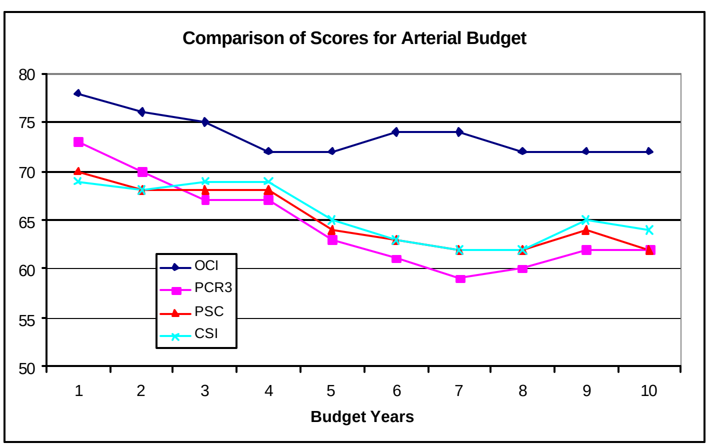
Index Used	Score Change		10 Year Deferred	Annual Added Cost
OCI	+6	68-74	$5,879,000	-
PCR_3	-10	71-64	$7,368,000	$148,900
PSC	-10	67-64	$9,086,000	$320,700
CSI	-9	66-65	$9,108,000	$322,900


Comparison of Deferred Cost for Overall budget
$10,000,000
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Deferred Cost for Arterial & Collector Budgets
$6,500,000
$6,000,000
$5,500,000
$5,000,000
$4,500,000
$4,000,000
$3,500,000
$3,000,000
$2,500,000
$2,000,000
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Deferred Cost for Residential Budgets
$3,500,000
$3,300,000
$3,100,000
$2,900,000
$2,700,000
$2,500,000
$2,300,000
$2,100,000
$1,900,000
$1,700,000
$1,500,000
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Scores for Overall Budget
80
75
70
65
60
55
50
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI


Comparison of Scores for Arterial Budget
80
75
70
65
60
55
50
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI

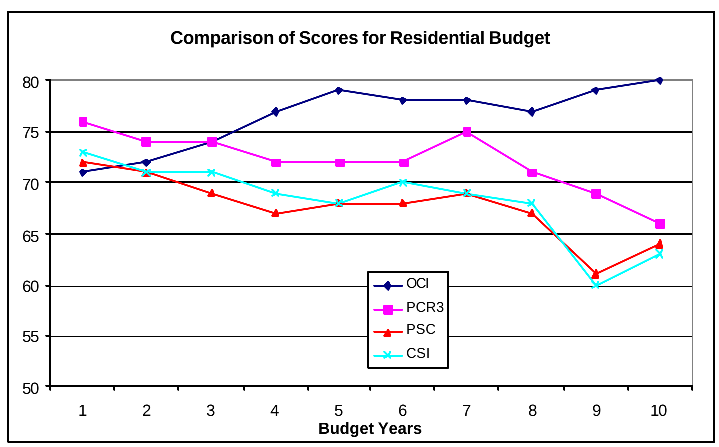

Comparison of Scores for Residential Budget
80
75
70
65
60
55
50
1 2 3 4 5 6 7 8 9 10
Budget Years
OCI
PCR3
PSC
CSI

Figure D12   Comparison of each index using PMS Network Analysis

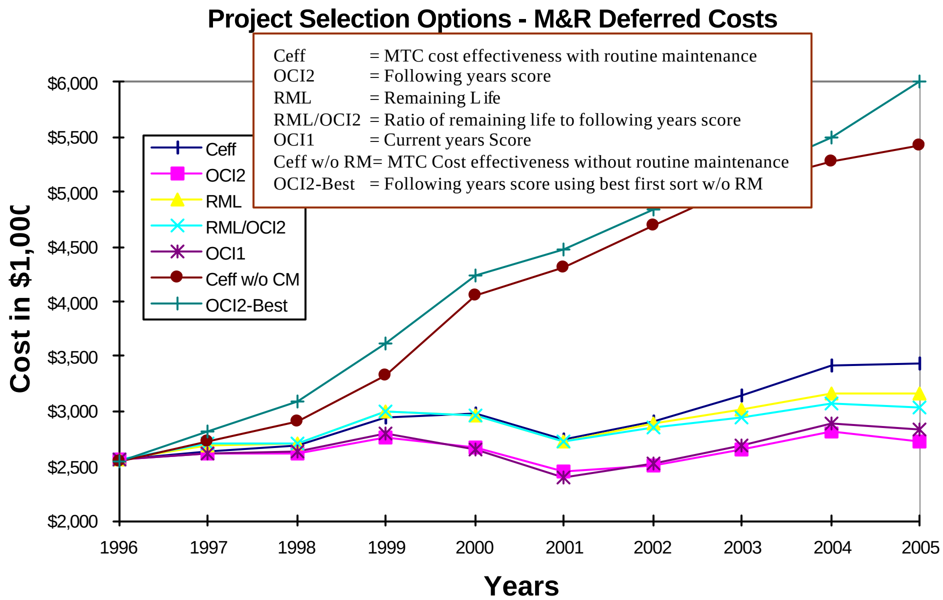


Figure D13   Deferred cost or back log for different index & sorting options – from Redmond, 1993

Evaluation of the Use of these Indices

The data used here is from the City of Issaquah, which has 49 centerline miles of streets and a population of 10,130 and a total annual MR&R budget of $650,000.

There are two methods of evaluating the use of the different pavement distress indices, which will be presented here. The first is a simple heuristic discussion based on the above figures and the second will be based on performing a detailed optimized 10 year budget analysis using each of these indices separately, with an evaluation of the relative deferred costs (back log) produced by each and the system wide average scores. Any differences in the network analysis runs are caused by the MR&R repair lists generated by each separate index. Since the primary objective associated with the use of any given index in a PMS is to provide the data required to manage your roadway network; this is obviously the best approach to evaluating the value or performance of each of these indices. The indices included here are the PCR_3, PSC, CSI and the OCI. Future work will include the PCR_1 and PCR_2. However, a comparison with these rating methods requires separate ratings of the same streets, over the same time period, using both walking and driving procedures or the simulation of the discrete data from the continuous data.

Default/Family curves were developed from each of these indices. Excepted for the CNI, all of these performed as expected. However, because of the higher score ranges associated with the PSC and PCR_3, the default curves developed from these indices had higher expected lives than for the OCI/WSC2 method. (Further details, including plots etc. should be included here, especially for low volume roads??)

The first method of evaluating these five indices is to discuss figures 5 through 8 above based solely on heuristic arguments. This approach has been taken over a more sophisticated statistical analysis for two reasons; first it is intuitive and easy to understand and second there was no simple statistical correlation found between the OCI index and the PCR_3, PSC or the CSI. In fact, even the correlation between the PCR_3, PSC and the CSI was relatively low or non-existent. This lack of correlation is obvious from the plots given above. However, in Figure 8 it appears that there is some kind of intermittent correlation between the PCR_3 and the other indices. This is most likely due to the discrete nature of selecting a secondary distress type when computing this index. Further analysis of this phenomenon is beyond the heuristic nature and objective of this analysis.

To begin with, it is intuitively obvious that if a given distress or condition resulting from a given distress is not included in the development of a given index, (in the data collection phase and/or index computation), it is impossible to expect your PMS related operations to reflect this condition, whether you are doing a simple prioritization (sort) based on this index or a detail network analysis. For example, see the relative index values for the OCI, PSC & PCR_3 in Figure 14 below and note the random scatter of the indices. This is also visible in Figures 5 through 8.

This same argument can be extended to one of the limitations in the PCR_3 method, in that if a given distress condition may or may not be included in the final score value, based on the fact that any one of four given distresses may be predominate at a given time makes it impossible to reliably make decisions based on any distress condition other than possibly fatigue cracking. Even this is suspect in that it may or may not be influenced by the same second distress for any given index calculation. If you look at this index in the above plots. you will see that it tends to have a more stair step type appearance than the others. This is due to the rather discreet type process of selecting a single second distress type based on the predominate secondary distress. This is typical of this type of procedure in any data collection operation. This is further exemplified in Figure 8, which appears to shows intermittent correlation over the data set.

Figure 7 shows a similar trend for the CSI, PSC and PCR_3. This shows that the PCR_3 is more heavily influenced by fatigue cracking (structural distress) and exhibits characteristics closer to the structural indices, the PSC and CSI than to the overall combined index, the OCI/ASTM. This is further exemplified in Figures 5 & 6 where both the structural indices exhibit higher score values over the full data set (all segments) then that of the OCI.

A careful look at the index values presented in the small portion of the database shown in Figure 14 shows the extreme variation in these numbers for each individual index and between segments. There is no way that these different indices can provide comparable repair lists or network analysis results.

Figures 9 & 10 shows the variation in the average system-wide-index scores for each of the indices discussed here. First, this Figure makes it clear that all indices discussed here are 20 to 30% greater than the OCI index. This is caused by the fact that fewer distresses are included in the calculation of these indices and that the methods used to compute these scores produce these relative numbers. The relative average score values between these indices could obviously be adjusted to better compare with each other by modifying the parameters associated with each. These numbers are based on 509 rated segments and were computed from the same data set simultaneously.

Evaluation of Each Index Using Network Analysis

In addition to the above discussion, the general independent random characteristics of the PSC, PCR_3 & CSI when compared to the OCI and when compared to each other, implies that any project selection process based on any one of these indices would be independent of the others. Therefore, to evaluate the value (or characteristics) of each of these independent indices, a detailed network analysis was performed using each and the results are summarized in Figure 11 and Figure 12. To allow for a reasonable comparison, the index scores for the CSI, PSC & PCR_3 were scaled to give similar average system wide score values to that of the OCI. The numbers in Figure 11 and the plots in Figure 12 were used to perform the following evaluation.

As has been shown in the CenterLine PMS Technical manual, (Figure 13) any variation in the index used to optimize the network can affect the results substantially. Figure 11 and Figure 12 are based on a ten-year analysis, using the same budget levels. These budget levels were established by developing an optimal solution using the OCI index. Thus all other runs are being compared to this option. No other changes were made in the various runs, other than to scale the individual index values for each index to enable a direct comparison with the OCI analysis and decision strategies. Figure 11 shows that the average system-wide-score drops by about 10 points for each of the non-OCI indices and that there is an average annual increase in the overall budgets of $148,900 for the PCR_3, $320,000 for the PSC and $322,900 for the CSI based on the year 10 deferred cost totals. The actual optimized complete budget was $650,000 for the OCI index. This means that you are loosing (or throwing away) about ½ of the average annual budget each year when using the PSC and CSI. This is caused by the inability of these indices to properly select the correct streets for repair and maintenance. This causes these streets to be pushed back in the decision process until the repairs for them are more expensive or they never do appear in the repair list. However, they still accumulate a larger and larger backlog or deferred cost.

The plots in Figure 12 further illustrate the characteristics of the four indices being evaluated. They also show the relative performance of each. Because of the inclusion of raveling the PCR_3 shows better performance than that of the PSC and CSI when looking at deferred costs, however, the score plots show it to be the worst at the end of the 10 year period with a continuing downward trend. The score trends tend to lag behind the trends in the deferred cost by 2-to-3 years.

It should be noted that most likely some of the projects which are not being picked because of a given index would be in real life and the actual ten-year performance would most likely vary from what is predicted here. However, the fact that it exists at all substantiates the increased benefit of using the OCI index for network level planning. This would obviously mean that it is also better at ranking projects at the single or current year level as well.

Figure 13 further substantiates this argument. This analysis is included in the CenterLine PMS Technical Manual and was done on the City of Redmond's database in the early 1990's. It shows that whenever you vary from a strait worst-first ranking/sort based on the OCI, your costs increase. This example actually shows a worst-case scenario when using the traditional cost effectiveness or cost benefit procedures or the simple best-first analysis.

CNI	CSI	OCI	PCR_3	PSC	LMY	ac1	ac2	ac3	lca1	lca1	lca3	lc1	lc2	lc3	tc1	tc2	tc3	mp1	mp2	mp3	rv1	rv2	rv3	egr	egp	upt1	upt2	upt3	ruts
59	7	0	67	0	1989	1105	532		70			14			16							3							
55	35	0	67	0	1995	6829						44			2							3							
60	33	0	67	0	1995	2468									3							3							
46	7	0	63	0		1917			63			180			18							3							
47	10	0	96	0	1997	126	8		61			199			21														
60	8	0	67	0	1995	3433			24									192				3							
98	6	0	96	0	1999	752	1		520			20			8			232	1120										
53	39	0	63	58	1981				192			112										3							
60	10	0	63	0	1981	152			370			12			2							3							
60	34	0	63	12	1981	8			500						1							3							
29	9	0	17	9		4750	100	26				89						548	40	480			2		240				
100	7	0	93	0		4740			250									432											
17	25	0	17	22		4000		2				85						1424	62				2		35				0.3
100	7	0	93	0		3960			365						2														
10	23	0	26	50		2054	20	18							15			210	50	12			3		20		50		
56	7	0	59	17		260	240	260											278	1100		3				120			
15	32	1	52	67	1999	200	1250	50	34			120	489		62	8		10	92	30		3		80	520	5613	120	20	
21	10	1	43	40		1096	2372		155	36.5		137		43.8	20	58			1169			2			20		36.5		0.5
98	9	2	85	0	1985	12			1806			30			96			338											
98	9	2	85	0	1985	12			1806			30			96			338											
52	23	3	52	62	1999	270	450	70	175			75			50			44		125		3		15	2	24			
93	10	4	100	0	1999	200			200			75																	
93	10	4	100	0	1999	200			200			75																	
44	9	4	59	48	1999	740	520	244	189	20		191	15	15	118	100		750		36		2				1524			
100	9	4	96	0	1997	760	108								5			250											
95	10	5	96	0	1999	128			85			54			9			434											
50	39	5	43	46	1997		1250			200					19			150				2				475			
99	10	5	96	0	1983	388			30			14			6			36											
91	11	6	96	0		120			185			123			3														
48	22	6	63	0	1989	200			25			102										3							
14	93	7	85	93		126	12	24							6			246			2								3

Figure D14 Sample database listing sort by OCI.

Final Discussion

All of the above indices are currently in use within the state and are referenced within this manual. For this reason the user of these data should have an awareness of how these indices differ. If the discrete steps used in the PCR_1 calculations are compensated for, the PCR_1 and WSC2/CSI values agree with each other within acceptable limits, the same is true for the PCR_2 and the CDI. However, the PSC and PCR_3 scores are in a world of their own, especially for alligator cracking in the case of the PSC, while the PCR_3 is all over the place. This is not necessarily of concern if an agency is using one index or the other, unless they are to change from one year's survey to the next. However, it could affect your MR&R decisions or the process used in making these decisions and obviously when comparing different indices between agencies.

Also, there is another area of concern which local agencies should be aware of. When considering how your agency's data will compare with other agencies within the state, extreme care should be taken of how you rate alligator cracking and patching and what index calculation procedure is being used. Alligator cracking dominates the PSC index and will be the key distress when comparing data between agencies; however, the potential for variation in how agencies rate patching and how each performs their relative maintenance has even a greater potential effect. For example, if an agency does a lot of relatively long skin or blade type patches or pre-leveling (can be considered an overlay at some point) and they classify these as patching and not a rehabilitation, they benefit substantially when compared to an agency which does not do this type maintenance or which does not classify it in the same manner. This type of patch covers the full pavement area in question and would thus be assigned an extent of 100%, if considered a maintenance patch. This would result in a much higher deduct than if the underlying distresses were rated separately or the patch is considered an overlay.

Another more common example would be in how an agency quantifies or defines a given distress. If this varies from one agency to another, and the same index is calculated, it will not produce the same results.

Summary and Recommendations for PSC Calculations

This index is based on a concept of equivalent alligator cracking, which attempts to convert Longitudinal Cracking, Transverse Cracking and Patching to an equivalent amount of Alligator Cracking. There is no sound physical meaning to this concept other than that WSDOT actually defines Longitudinal Cracking and Patching as different severities of Alligator Cracking. However, if it is to be used for state-wide comparisons it becomes extremely important that your agency use the same MR&R practices and rating procedures as WSDOT if you are to try to compare your data to theirs and other agencies. Unfortunately, this is incompatible with local agency needs in pavement management and could force agencies into adopting MR&R practices which are not optimal for their individual roadway networks and funding situations. Therefore, local agencies should not use this index for reasons other than reporting to the WSDOT and/or CRAB.

Summary and Recommendations for PCR_3/StreetWise Calculations

The primary reason given for the development of this index was to develop a paper and pencil procedure for rating the pavement and selecting MR&R actions for small agencies. Ironically, the PAVER/ASTM method was originally developed as a paper and pencil system and thus the WSC2 or CDI method can be done manually as well. (See the US Corp of Engineers, Technical Report M-294, Oct 1981). Also, the PCR_1 and PCR_2 can be used as a paper and pencil based method in a much easier manner than StreetWise, one page of deduct matrices and one step/line of calculations versus four pages of matrices and several calculation steps. However, there is one advantage when comparing the PCR_3 to the PCR_1 or PCR_2 methods. More detailed data is collected (even though it is not fully used) when using the StreetWise (PCR_3) method and this data could be used to compute the PCI, CDI or PSC indices at a later date.

The values produced by the PCR_3 index are quite different from any of the other indices currently in use. Therefore, care should be taken in comparing it to other indices, see Figures 1 thru 8. Also, if you are going to collect detailed data; use it, why go back to using a matrix method when you could just as easily use continuous deduct curves as in the ASTM procedures? Also distress types other than the five used in this method are of value to the decision process, especially for maintenance operations. Also, only two distresses are reflected in the final PCR_3 score and the second distress can vary from one segment to the next and one survey to the next. This presents some concerns when prioritizing streets based in the PCR_3 in that streets with a different second distress type cannot be differentiated and the other distresses are not included at all. Also, what happens if there is no alligator (fatigue) cracking, but other distresses are present, are these segments being prioritized properly? Raveling is the more predominate or controlling distress in low volume roads and in these cases, raveling most often occurs without alligator cracking.

StreetWise is also referred to as a Pavement Management System (PMS). The term PMS is an extremely general term but to refer to the StreetWise procedures, as a PMS is somewhat of an overstatement. At a minimum a PMS has a database, budget planning and scenario comparison capabilities and the ability to analyze the impact of your decisions. Look at the AASHTO definition of a PMS in "AASHTO Guidelines for Pavement Management Systems, July 1990". A better description might be a pavement management procedure, which follows or extends the natural process used by pavement rehabilitation and maintenance decision makers. That is, look at the street and decide what should be done to it and when it should be repaired based on existing funds. StreetWise is really just a rating system which suggests that the user sort or prioritize its results on this rating and assign a MR&R action based on five score ranges or groups defined by these scores. This is not a PMS by the AASHTO definition.

However, a full-blown PMS is not needed or does not necessarily even work for extremely small agencies and therefore, this procedure is adequate for its intended application if the PCR_3 index contains the distress data needed to manage your roadways. Also, this procedure could be simplified further by adding the matrices and some equations to a simple MS Excel spreadsheet or a little code to an MS Access form or database. It's hard to believe that even the smallest agency doesn't have a PC. Also, if this is done, it's just as easy to add the deduct curves as it is the matrices to the same spreadsheet. This would be less than a days work for someone skilled in the programming of a spreadsheet.

Appendix E

CenterLine
Pavement Distress Definitions

CenterLine Pavement Raters Manual

MEASUREMENT RESEARCH CORPORATION
4126 4th Street NW - Gig Harbor, WA 98335
(253) 851-3200 - FAX (253) 851-4334
e-mail mrc@harbornet.com

CenterLine Pavement Raters Manual
Preface

This document originated with a draft manual developed in the early 1990's by over 20 Washington State Local Agencies, through the NWPMS User's Group. Using this draft and over ten years of experience (over 30,000 centerline miles of video and manual surveys) Measurement Research Corporation has refined this original manual to what is presented here. It differs from the current (1999) WSDOT Local Programs rater's manual in a few key areas and includes additional information (See Appendix D for full details). The primary differences include the rating of patching, inclusion of utility patching, differed naming for longitudinal crack types and some differences in how various distresses are quantified and defined. These changes reflect requests made by the original authors (agencies), which were rejected or changed by the WSDOT in their review and publishing process. It also contains rigid distress rating methods and roadside inventory material. If you are using the CenterLine PMS software or if you wish to use your resulting survey to properly model maintenance and repair operations you should use this manual and its related definitions and procedures.

You are free to copy this manual or a copy of this manual is available on request from MRC. A copy is also included in the CenterLine PMS help system in both an Acrobat pdf or word file format. A field (or smaller) version of this manual is also available. You are incurraged to use this manual as written, however, if your agency requires custom modifications or the development of a special rating manual, you are welcome to use this manual as a starting point and modify it and use it as your own. The only requirement is that you give MRC an acknowledgement as to the origin of your manual.

MRC currently provides manual rating services for over 3000 centerline miles each year for Washington State Local Agencies using this manual. This includes both walking and windshield rating surveys.

This manual and/or its procedures are currently in use by several Washington State Local Agencies. This includes the following agencies.

City of Bellevue *	City of Bellingham *	City of Bonney Lake
City of Bremerton	City of Cheney	City of Colville
City of Edgewood	City of Everett *	City of Federal Way *
City of Fife	City of Fircrest	City of Gig Harbor
City of Issaquah	City of Kenmore	City of Kent
City of Kirkland *	City of Lacey	City of Lake Forest Park
City of Lakewood	City of Lynnwood	City of Mountlake Terrace
City of Olympia *	City of Othello	City of Pullman
City of Puyallup	City of Redmond *	City of Renton *
City of Ritzville	City of SeaTac *	City of Seattle *
City of Shoreline	City of Spokane *	City of Sumner
City of Tacoma *	City of University Place	City of Vancouver *
Pierce County *	San Juan County	Spokane County
Snohomish County *		

* These are some of the agencies that were involved in the original development of this manual. Several other agencies not listed here were also involved along with the UW, CRAB, WSDOT and AWC.

CENTERLINE PMS

Pavement Distress Rating Field Manual
Inspection Procedures and Guidelines

These inspection procedures offer a method of determining pavement condition by observing and recording the presence of specific types and severities of defects, or distresses in the pavement surface. The elements of pavement condition rating are as follows:

1. The <u>type</u> of defect.
2. The <u>severity</u> of the defect. How bad is it?
3. The <u>extent</u> to which the road surface is affected by the defect.

There are several types of defects and several possible severities and extents for each defect. These are described and illustrated for flexible and rigid pavements in the following pages of this manual. For more general discussion and details see Appendix A. See Appendix B for the abbreviated field notes. These notes should be carried on your clip board at all times. Appendix C contains information on the roadside inventory and the filling out of the rating forms While Appendix D gives details on how the various pavement scores are computed and a comparison of these different index calculations.

<u>This manual covers both walking/automated and windshield rating procedures.</u>

Walking/Automated Procedures
In general, a walking survey records extent data separately for each distress severity. Extent data is recorded as the actual area, length or count depending on the distress types. Each distress is measured over the full pavement area specified by the individual agency. This is either the full pavement area, a single lane or a small sample unit area (generally >= 10%). It is highly recommended that sample unit procedures not be used and that the full surface area be rated.

Windshield Procedures
A windshield survey is done from within a moving vehicle by having an individual observe the pavement, (generally a single lane), while driving at about 10 to 15 mph. The individual distress severity is defined by the single predominate severity and extent is grouped into ranges to allow the rater to visually estimate the distress data more easily. The extent data is generally further grouped by rating based on percent of wheel paths in place of actual area or length.

Distress Definitions
The description of the distresses and their associated severities does not change between these two methods. However, the extent is based on discrete ranges and wheel path percentages and the predominate severity for the windshield method. While actual areas, lengths and counts and all three severities are recorded when using a walking distress survey. See Appendix B for a detailed breakdown of the walking and windshield severity and extent descriptions and quantifications for both rigid and flexible pavements.

Flexible Pavement Distresses

1. Rutting and Wear

Rutting is a surface depression within the wheel path. Rutting results from a permanent deformation in any of the pavement layers (or the sub-grade materials). Consolidation or lateral movement of the materials due to traffic loads usually causes it. When the upper pavement layers are severely rutted, the pavement along the edges of the rutted area may be raised. Usually, the rutting occurs gradually across the wheel path, reaching a maximum depth in the center of the wheel path. Ruts are most obvious after rainfall when they are full of water. Wear is surface depression in the wheel path resulting from tire abrasion. No differentiation is made between rutting and wear.

Severity: Is defined as the average depth of an individual rut measurement, general taken at the center of the wheel path, or as a visual average.

Extent: The extent of rutting is assumed to be the full length of the segment. Average the rut measurements taken over the full segment length. Use sags & humps for localized rutting (less than 50 to 60% of roadway surface is rutted). If less than ¼ inch do not rate rutting. When using automated equipment, include the maximum value and standard deviation.

Measure: Take measurements in as many locations as is practical and average them or simply visually estimate the average. If estimates are used collect the data to the nearest ¼ inch. Estimates are the preferred method primarily because of traffic hazards and the time involved in collecting the data. Since the extent is assumed to be 100%, only the single severity level is entered or recorded. Rutting should no be rated if it is not visible with the human eye or if it is less than ¼". Even with specialized equipment you may want to ignore rutting below this level.

2. Fatigue (Alligator) Cracking

Fatigue cracking is associated with wheel loads and is usually limited to areas of repeated traffic loading. The cracks surface initially as a series of parallel longitudinal cracks within the wheel path that progresses with time and loads to a more branched pattern that begins to interconnect. The point at which several discontinuous longitudinal fatigue cracks begin to interconnect is defined as alligator cracking. Eventually the cracks interconnect sufficiently to form many pieces, resembling the pattern of an alligator. On narrow, two lane roads, fatigue cracking may form along the centerline rather than in the customary wheel paths. In parking lots, at intersections and on low volume roads it is common to have fatigue cracking outside of the wheel path.

Almost always, the pattern of the cracking (the longer dimension of the connected cracks) is parallel to the roadway or direction of vehicle travel. However, fatigue cracking occasionally occurs in a pattern transverse to the roadway direction because of poor trench compaction, settlement, or frost action. Pot holes and other occurrences of destroyed or missing pavement are accumulated as high severity alligator cracking and may also be noted in the comment area of the field form.

Severity: **Low** Multiple branched inner connecting longitudinal discontinuous thin cracks with no spalling. Single and intermittent longitudinal cracks are recorded as the Longitudinal Fatigue Crack distress type, which is a separate distress type.

Medium Cracking is completely interconnected and has fully developed an alligator pattern. Some spalling may appear at the edges of cracks. The cracks may be greater than ¼ - inch wide, but the pavement pieces are still in place.

High The pattern of cracking is well developed. Spalling is very apparent at the crack. Individual pieces may be loosened and may rock under traffic. Pieces may be missing and appear as though they could be easily removed. Pumping of fines up through the cracks may be evident.

Extent: The extent of alligator cracking is measured in square units or as a percentage or area or wheel path.

Measure The area associated with each separate crack severity should be recorded.

3. Longitudinal Fatigue Cracking

All Longitudinal cracks run roughly parallel to the roadway centerline. Longitudinal cracks associated with the beginning of fatigue (alligator) cracking are generally discontinuous, broken, and occur in the wheel path.

4. Longitudinal Non-Fatigue Cracking

Longitudinal non-fatigue cracks may be caused by a poorly constructed paving joint or from reflective cracks caused by joints and cracks beneath the surface course, including joints and cracks near the edge of the pavement and from underlying PCC slabs. These types of cracks are not load associated. Low severity non-fatigue related longitudinal cracking looks very similar to low severity fatigue or alligator cracking and care needs to be taken to separate these two distresses properly. High severity non-fatigue related longitudinal cracks can exhibit large amount of localized fatigue cracking.

Severity: **Low** Cracks have very little or no spalling along the edges and are less than ¼ inch wide. If the cracks are sealed and the width of the crack prior to sealing is invisible, they should be classified as Low Severity, this is true for all sealed cracks.

Medium Cracks have little or no spalling but they are greater than ¼ inch in width. There may be a few randomly spaced low severity connected cracks near the main crack or at the corners of intersecting cracks.

High Cracks are spalled and there may be several randomly spaced cracks near the main crack or at the corners of intersecting cracks. Pieces are visibly missing along the crack, or the two sides of the crack do not match. For longitudinal fatigue cracks, this longitudinal cracking will eventually form alligator cracking.

Extent: The extent of longitudinal cracking is measured in linear units or as a percentage of segment length for one or both wheel paths.

Measure: The length of each individual crack severity should be recorded. For reflective cracks any associated fatigue cracks can be rated separately or included as high severity longitudinal cracks.

5. Transverse Cracking

Transverse cracks run roughly perpendicular to the roadway centerline. They may be caused by surface shrinkage due to low temperatures, hardening of the asphalt, or cracks in underlying pavement layers such as PCC slabs. They may extend partially or fully across the roadway. Include cracks that may be the first stage of block cracking. Longitudinal non-fatigue cracks and transverse cracks receive the same score reduction and can be mixed or combined for convenience when rating

Severity: **Low** The cracks have very little or no spalling along the edges and are less than ¼ inch in width. If the cracks are sealed and the width of the crack prior to sealing is invisible, they should be classified as Low Severity, this is true for all sealed cracks.

Medium The cracks have little or no spalling but they are greater than 1/4 inch in width. There may be a few randomly spaced low severity connected cracks near the main crack or at the corners of intersecting cracks.

High Cracks are spalled and there may be several randomly spaced cracks near the main crack or at the corners of intersecting cracks. Pieces are visibly missing along the crack, or the two sides of the crack may not match.

Extent: The extent of transverse cracking is measured in linear units or as counts per unit length. If using counts the crack should cross at least one wheel path before it is counted.

Measure: The length (or count) for each severity should be recorded. The actual length is preferred.

6. Raveling and (Aging or Weathering)

Raveling and aging are pavement surface deterioration that occurs when aggregate particles are dislodged (raveling) or oxidation causes loss of the asphalt binder (aging); aging is generally associated with raveling. An ACP pavement loses its smooth surface and begins to appear very open and rough like very coarse sandpaper. The severity is rated by the degree of aggregate and binder loss. Rate the overall severity within the segment as the predominate level. This is an extremely important distress especially on low volume roads or roads that are failing for reasons other than structural or fatigue cracking.

This distress is measured or observed differently depending on whether the road surface is BST or ACP. Care should be exercised when rating chip sealed pavements as they tend to look raveled because of the inherent nature of the chip seal surface. However, raveling in chip sealed pavements (loss of aggregate) actually results in a condition of excess asphalt, and should be rated as raveling (see Flushing /Bleeding).

Severity: **Low** The aggregate or binder has started to wear away but has not progressed significantly. The pavement appears only slightly aged and slightly rough.

Medium The aggregate or binder has worn away and the surface texture is moderately rough and pitted. Loose particles may be present and fine aggregate is partially missing.

High The aggregate and/or binder have worn away significantly, and the surface texture is deeply pitted and very rough. Fine aggregate is essentially missing from the surface, and pitting extends to a depth approaching one half (or more) of the coarse aggregate size.

Extent: The extent of raveling is estimated and expressed relative to the total traveled surface area. The recommended ranges for estimated extent are given below; you may record areas or percentages, if you wish.

Localized **1** Localized distressed areas, usually in the wheel paths.

Wheel Path **2** Majority of wheel tracks are affected, but little or none elsewhere.

Entire Lane **3** Most of the lane is affected.

Measure: The extent is generally recorded as 1, 2 or 3. For example 3L would be entered on the form for low level raveling over the full surface area. Record only the predominate severity.

7. Flushing/Bleeding

Flushing and bleeding is indicated by an excess of bituminous material on the pavement surface, which presents a shiny, glass-like reflective surface that may become sticky in hot temperatures. Wheel path refers to tire tracking area and may be used to represent the condition of only one wheel track being heavily involved.

This distress is measured or observed differently depending on whether the road surface is BST or ACP. In BST pavements, loss of aggregate (raveling), commonly referred to as "chip loss," leaves the binder exposed. This condition looks like flushing, and is rated as raveling.

Severity: **Low** Minor amounts of the aggregate have been covered by excess asphalt but the condition has not progressed significantly.

Medium Significant quantities of the surface aggregate have been covered with excessive asphalt, however, much of the coarse surface aggregate is exposed, even in those areas showing flushing.

High Most of the aggregate is covered by excessive asphalt in the affected area. The area appears wet and may be sticky in hot weather.

Extent: The extent of flushing is estimated and expressed relative to the total traveled surface area. The recommended ranges for extent are given below, you may record areas or percentages in place of this if you wish.

Localized **1** Localized distressed areas, usually in the wheel paths.

Wheel Path **2** Majority of wheel tracks are affected, but little elsewhere in the lane.

Entire Lane **3** Most of the lane is affected.

Measure: The extent is generally recorded as 1, 2 or 3. For example 3L would be entered on the form for low level flushing over the full surface area. Record the predominate severity only.

8 Maintenance Patching & 9. Utility Patching

A patch is an area of pavement that has been replaced or covered with new material to repair the existing pavement or for utility access. A patch is considered a defect no matter how well it is performing. A patched area or adjacent area usually does not perform as well as the original pavement. While appropriately done repairs are an asset rather than a liability to the life of the pavement, the fact that they were required (other than for utility work) usually indicates some failure in the pavement structure. Some roughness is often associated with this distress. In general, a patch is less than a typical rehabilitation in size and less than full pavement length and/or width. Some agencies may have patches as long as the work defined by another agency as rehabilitation. Temporary patches are included in this distress category. If a major portion of the segment has been re-paved, this is not a patch.

<u>Utility cut patches are rated and recorded separately using the same definitions given here</u>. Utility patches can be hard to distinguish from a full depth maintenance patche. However, if you consider the overall condition of the roadway (a maintenance patch is generally associated with a poor pavement), the location of obvious utilities near the patch (water, gas, power or telephone etc.) and your agencies patching practices, you can usually resolve the patch type.

Severity: **Low** Patch has little or no distress of any type and no change in ride quality

Medium Patch has medium severity distress of any type and/or moderately reduced ride quality

High Patch has high severity distress of any type and/or severe reduction in ride quality

Extent: The extent of patching is measured in square units.

Measure: All other distresses (e.g., rutting, raveling, cracking etc.) are recorded within a patch as if the patch does not exist. Rate the quality of the patch separately as to the amount of distress and any related deterioration to ride quality. The PMS software will account for any duplication in the quantification of these distresses. Open cracks around full depth patches should be rated as longitudinal and transverse cracks.

10 Corrugation and Waves

This distress category covers a general form of surface distress, which is not limited to the wheel path, although they may occur in the wheel path. The distress may occur in isolated areas, such as at intersections, or it may occur over a large part of the roadway surface. Corrugations and waves are regularly occurring transverse undulations, in the pavement surface.

Corrugations occur as closely spaced ripples, while waves are undulations whose distance from peak to valley is more than 3 feet.

Severity: The severity of corrugation is defined as the maximum vertical deviation from a 10-foot straight edge placed on the pavement parallel to the centerline of the roadway.

Low	1/8 inch to 2 inches per 10 feet.
Medium	2 inches to 4 inches per 10 feet.
High	Over 4 inches per 10 feet.

Extent: The extent of corrugations is expressed in square units and is measured over the entire survey area.

Measure: Record the square units separately for each severity.

11 Sags and Humps

This distress usually occurs in isolated areas of the roadway surface. Sags and humps are localized depressions or elevated areas of the pavement that result from settlement, pavement shoving, displacement due to subgrade swelling, or displacement due to tree roots. Localized rutting, such as at intersections, is recorded as sags and humps. This distress is also a good place to record any distress or condition that does not fully comply with any of the other distresses. If this is the case, care should be taken to record any needed details in the comments section of the rating form.

Severity: The severity of sags or humps is defined as the maximum vertical deviation from a 10 foot straight edge placed on the pavement parallel to the center line of the roadway.

Low	1/8-inch to 2 inches per 10 feet.
Medium	2 inches to 4 inches per 10 feet.
High	Over 4 inches per 10 feet.

Extent: The extent of sags and humps is expressed in square units.

Measure: Record the square units area for each separate severity.

12 Block Cracking

Block cracks divide the pavement surface into nearly rectangular pieces with cracks that intersect at about 90 degrees. Block cracking is caused principally by shrinkage of the asphalt concrete and daily temperature cycling. It is not load-associated, although load can increase the severity of individual cracks. The occurrence of block cracking usually indicates that the asphalt has hardened significantly through aging. Block cracking normally occurs over a large portion of the pavement area including non-traffic areas. However, various fatigue related defects may occur in the same segment. Block cracking always begins as equally spaced transverse cracks at 40 to 60 foot intervals.

Severity: The severity of block cracking is defined by the average size of the blocks.

Low	9 X 9 feet and larger blocks.
Medium	Greater than 5 X 5 feet to 8 X 8 feet blocks.
High	2 X 2 feet to 4 X 4 feet blocks.

Extent: The extent of block cracking is square units or percent of length.

Measure: Measure the typical size of the blocks and select the appropriate severity. Record the unit area.

13 Pavement Edge Conditions

Edge raveling occurs when the pavement edge breaks away from roadways without curbs or paved shoulders. However, edge conditions can still occur with paved shoulders and/or curbs. The crack between the curb or gutter is also included as edge cracking. Edge patching is the repair of this condition. The "lane less than 10 feet" distress indicates that the edge raveling has progressed to the point where the pavement width from the centerline to the outer edge of roadway has been reduced to less than 10 feet.

Severity: The severity of Pavement Edge Condition is defined as follows.

Low	**Edge Raveling**
Medium	**Edge Patching**
High	**Edge Lane Less Than 10 Feet – width to centerline < 10'**

Extent: Actual length of edge failure. If both sides are fully raveled, this would be 200% raveling,

Measure: Accumulate the lengths along the surveyed lane for each type/severity of edge defect as it occurs. This can be recorded/estimated as actual lengths or the percent of length. This results in 2 times the length or 200%, if the cracking is the full segment length on both sides.

14 Crack Seal Condition

Rate the condition of any existing crack (or joint) sealant. Crack sealant is generally poured over the surface of existing cracks to prevent water form entering the cracks. Some agencies rout or dig out cracks prior to sealing them. This distress is, in general, an inventory of the existing sealed cracks and is used to manage a crack seal program. Crack seal condition is not used in the score calculations, only for crack seal maintenance management operations.

Severity:

Low	Sealant in good to excellent condition.
Medium	Hairline cracks in the sealant allowing only a minimal amount of water to pass.
High	The sealant is severely cracked (or worn away) and may allow significant quantities of water to pass.

Extent: The extent of crack sealing is quantified as the percent of the total length of the cracks (or joints) in the segment that exhibit the seal condition being measured.

Measure: Estimate percent of the length of cracks and joints that exhibit each severity of seal condition. If you are monitoring this distress, transverse cracking should be measured in length units and not counts. The ratio of sealed crack lengths to actual (sealed + unsealed) cracks (alligator, transverse and longitudinal) should provide a true percentage of sealed cracks for a given section of pavement. When rating crack type distresses, a properly sealed crack is always rated separately as a low severity crack. If the crack seal has failed the crack should be rated using the actual severity if visible or use the crack width within the sealant.

Rigid Pavement Distresses

PORTLAND CEMENT CONCRETE DISTRESSES

For distresses 1 though 6, enter the number of slabs that contain the given distress. Be sure to count the total number of slabs in the segment and include this on the rating form. For blowups (#7) enter the number of occurrences and for the wear (#8) enter the average depth. If two slabs are associated with a single distress, such as faulting or pumping at joints between slabs, be sure to record this only once per slab.

1. Cracking

The cracking defects are irregular breaks that may form transversely, longitudinally, or diagonally within a (PCC) panel. Construction joints, which are straight and obviously formed or cut, are not considered cracks.

Severity:

The severity of the cracking is quantified by the number of cracks in a panel.

Low	1 crack per panel
Medium	2 or 3 cracks per panel
High	4 or more cracks per panel

Extent: Number of slabs with this severity

2. Joint and Crack Spalling

Spalling occurs when fragments break or chip off along the edges of the pavement joints or cracks. These spalls may be large wedges or flakes, or they may be only lost pieces of aggregate.

Severity: The severity of joint and crack spalling is quantified by the typical size of the spalls in the joints and cracks that are spalled.

Low	1/8-in. to 1-in. spalls.
Medium	1-in. to 3-in. spalls.
High	Greater than 3-in. spalls.

Extent: Number of slabs with this severity.

3. Pumping and Blowing

Pumping and blowing refers to the ejection of water from underneath the pavement. Cyclic wheel loadings eject water through or along the transverse or longitudinal joints and cracks, or at panel edges. The ejected water also carries fine soil particles, thus eroding the pavement foundation. Pumping is recognized by the visible fine materials left on the dried surface of the roadway and/or shoulder areas. Because pavement rating is not done during wet weather, pumping activity would not generally be observed directly.

Severity: The severity of pumping is quantified by the type and amount of the evidence observed at each joint or crack. Either depression of the shoulder at the joint/crack or stains on the shoulder showing fine subgrade soil particles are evidence of pumping.

Low	Slight depression evident, little or no staining.
Medium	Moderate depression with obvious staining.
High	Severe depression and/or significant staining.

Extent: Number of slabs with this severity.

4. Faulting and Settlement

Faulting and/or settlement occurs when abutting pavements separate vertically at the joints or cracks caused by settling or uplifting. The result is a "step" difference between the adjoining pavement surfaces. Settlement is defined as differences in height between pavements across a longitudinal joint or crack. Generally, faulting will be found as a downward "step" across a transverse joint or crack in the direction of travel.

Severity: The severity of faulting or settlement is quantified by the vertical distance between panels or pavement surfaces.

Low	1/8-in. to 1/4-in. faulting or settlement at joints or cracks.
Medium	1/4-in. to 1/2-in. faulting or settlement at joints or cracks.
High	Over 1/2-in. faulting or settlement at joints or cracks.

Extent: Number of slabs with this severity.

5. Patching

Patching is a temporary or semi-permanent replacement of all, or part, of a (PCC) slab with a flexible or rigid pavement material. A new, full size, replacement slab is NOT a patch.

Severity:

Low	Patch is in good condition.
Medium	Patch shows slite to moderate distress and ride quality.

High Patch shows severe distress and low ride quality.

Extent: Number of slabs with this severity.

6. Raveling or Scaling

Pavement raveling or scaling is the progressive disintegration of the pavement from the surface downward, or from the edges inward, by the dislodgment of aggregate particles. In severe cases, the surface is very rough and irregular.

Severity: The severity of raveling or scaling is determined from personal judgment on the basis of the following descriptions:

- **Slight** The aggregate or binder has started to wear away but has not progressed significantly. The pavement appears only slightly aged and slightly rough.
- **Moderate** The aggregate or binder has worn away and the surface texture is moderately rough and pitted. Loose particles may be present and fine aggregate is partially missing from the surface.
- **Severe** The aggregate and/or binder have worn away significantly, and the surface texture is deeply pitted and very rough. Fine aggregate is essentially missing from the surface, and pitting extends to a depth approaching one half the coarse aggregate size or greater.

Extent: Number of slabs with this severity.

7. Blowups

Blowups are the shattering or upward bucking of pavement panels at transverse cracks or joints. The occurrence is caused by the expansion of a PCC slab when all available room for expansion has been previously taken and the PCC slab is tightly confined. The defect is seldom, if ever, observed in action, but the evidence is obvious. The rater will most likely find a patch where the blowup happened. Usually the patch will include parts of two or more slabs or even the full slabs which have been removed in adjacent lanes across the whole roadway. Raters must assure themselves that the patching was not for utility work or some other activity. The patch is also included in the patching category.

Severity: **Not defined.**

Extent: The number of occurrences in the segment are counted and recorded.

8. Wear

Wear is a surface depression in the wheel path resulting from tire abrasion (usually studded tires).

Severity: The severity is the average wear (rut) depth in the wheel path for the segment or sample. Automated systems may accurately record mean, maximum, standard deviation, and other useful data. Enter the average visual depth of the wear in the wheel path to the nearest ¼"

Extent: The extent of wear is assumed to be the full length of the segment.

Appendix F

Rating Forms

FLEXIBLE PAVEMENT INSPECTION FORM Sq#

Date: PAVEMENT/SEGMENT DATA Left Right

Str/Sq#:			Sg Length:			Sidewalk Type:		
Str. Name:			Sg Width:			Sidewalk Width:		
From Desc:			Shldr/curb Type			Sidewalk Cond.		
To Desc:			Shldr. Width:			Sidewalk %Comp		
Bus Routes:		Speed	Min. Curb Ht.			Ramped Curb/Fr		
# Casting:		Lanes	StormSys.			Ramped Curb/To		
Pav. Type:		Class	Parking:			Striping:		
Observer:		Exempt	Bike Lanes:			Lighting:		

COMMENTS: (Including bridge, median, lane width and excessive crown information etc.) ______________________________

____

____

____

____

DISTRESS TYPES		GRAPHIC
1. Rutting & Wear __________	9. Utility Patching (AR)	
2. Alligator/Fatigue Cracking (AR)	10. Corrugations & Wave ____________	
3. Long. Crack - Structural (LF)	11. Sags & Humps ____________	
4. Long. Crack - Reflective (LF)	12. Block Cracking ____________	
5. Transverse Crack (LF)	13a. Edge Raveling Ext. _____________	
6. Raveling __________	13b Edge Patching Ext. _____________	
7. Flushing __________	14. Crack Seal Condition ___________	
8. Maintenance Patching (AR)	15. Ride Quality ___________	

.	DISTRESS TYPES							
	2	3	4	5	8	9	13	
Direction								
Fwd								
Rev								
Total L								
Severity M								
Data H								
Previous L								
Rating M								
Data H								

RIGID PAVEMENT INSPECTION FORM **Sq#**

Date: PAVEMENT/SEGMENT DATA Left Right

Str/Sq #:			Sg Length:			Sidewalk Type:		
Str. Name:			Sg Width:			Sidewalk Width:		
From Desc:			Shldr/curb Type			Sidewalk Cond.		
To Desc:			Shldr. Width:			Sidewalk %Comp		
Bus Routes:		Speed	Min. Curb Ht.			Ramped Curb/Fr		
# Casting:		Lanes	StormSys.			Ramped Curb/To		
Pav. Type:		Class	Parking:			Striping:		
Observer:		Exempt	Bike Lanes:			Lighting:		

COMMENTS: (Including bridge, median, lane width and excessive crown information etc. here) ___________________________

____

____

____

____

DISTRESS TYPES		GRAPHIC
1. Cracking # of panels	5. Patching # panels	
2. Joint/Crack Spalling # panels	6. Raveling or Scaling # panels	
3. Pumping & Blowing # panels	7. Blowups (enter # of Ocur)_____	
4. Faulting/Settlement # panels	8. Wear: (enter avg depth) ______	

	DISTRESS TYPES – Enter # of Panels						
Fwd	1. Cracking	2. Spalling	3. Pumping	4. Faulting	5. Patching	6. Raveling	# of panels in segment:
Rev	1/panel	1/8' - 1"	slight depr	1/8" - 1/4"	Good		
Low							
	(2 or 3)/pl	1" - 3"	mod dp,slst	1/4" - 1/2"	Fair		
Medium							
	> 3/pl	> 3"	sev. depr/st	> 1/2 "	Poor		
High							
Total L							
Severity M						____blowups	_____panels
Data H							
Previous L							
Rating M							
Data H							

Pierce County FLEXIBLE PAVEMENT INSPECTION FORM

PAVEMENT/SEGMENT DATA

Date: ______________________ Observer:

On#/Sq #		Sg Lngth:		Latest Rating:	
Street Name:		Sg Width:		Function Class:	
From Desc:		FMP:		Pavement Type:	
To Desc:		TMP:		Surface Type:	

1. Rutting & Wear **L M H**	8. Corrugations & Wave **Yes No**	# of Lanes:	
5. Raveling **Loc Whl Lan**	9. Sags & Humps **Yes No**	Last Maint:	
6. Flushing **Loc Whl Lan**	11. Crack Seal Condition **Yes No**	District\City:	

	2. Alligator			3. Longitudinal			4. Transverse			7. Patching (Chip Seal)	
	Hairline < ¼”	Spalling	Spalling /Pumping	< ¼” wide	> ¼” wide	Spalled	< ¼” wide	> ¼” wide	Spalled		
										10. Edge Condition (Raveling)	
Tot										7.	10.

PAVEMENT/SEGMENT DATA

Date: ______________________ Observer:

On#/Sq #		Sg Lngth:		Latest Rating:	
Street Name:		Sg Width:		Function Class:	
From Desc:		FMP:		Pavement Type:	
To Desc:		TMP:		Surface Type:	

1. Rutting & Wear **L M H**	8. Corrugations & Wave **Yes No**	# of Lanes:	
5. Raveling **Loc Whl Lan**	9. Sags & Humps **Yes No**	Last Maint:	
6. Flushing **Loc Whl Lan**	11. Crack Seal Condition **Yes No**	District\City:	

	2. Alligator			3. Longit udinal			4. Transverse			7. Patching (Chip Seal)	
	Hairline < ¼”	Spalling	Spalling /Pumping	< ¼” wide	> ¼” wide	Spalled	< ¼” wide	> ¼” wide	Spalled		
										10. Edge Condition (Raveling)	
Tot										7.	10.

FLEXIBLE PAVEMENT INSPECTION FORM   Sq# ______

Date: PAVEMENT/SEGMENT DATA   Left   Right

Str/Sq#:				Sg Length:			Shldr/curb Type		
Str. Name:				Sg Width:			Shldr. Width:		
From Desc:				Striping:			Sidewalk Type:		
To Desc:				Lighting:			Sidewalk Width:		
Bus Routes:		Speed		Bike Lanes:			Sidewalk Cond.		
# Casting:		Lanes		Parking:			Sidewalk %Comp		
Pav. Type:		Class		Curb Ht.			Ramped Curb/Fr		
Observer:		Exempt		StormSys.			Ramped Curb/To		

1. Rutting & Wear _________	10. Corrugations & Wave ___________	13b Edge Patching Ext. _________%
6. Raveling _________	11. Sags & Humps ___________	13c Edge Lane < 10' _________%
7. Flushing _________	13a. Edge Raveling Ext. ___________%	14. Crack Seal Condition _______%

Direction Fwd Rev	2	3	4	5	8	9	13	
Total L								
Severity M								
Data H								

Name:	From:	To:
1. Rutting & Wear _________	10. Corrugations & Wave ___________	13b Edge Patching Ext. ________%
6. Raveling _________	11. Sags & Humps ___________	13c Edge Lane < 10' ____________%
7. Flushing _________	13a. Edge Raveling Ext. ____________%	14. Crack Seal Condition _______%

Direction Fwd Rev	2	3	4	5	8	9	13	
Total L								
Severity M								
Data H								

Name:	From:	To:
1. Rutting & Wear _________	10. Corrugations & Wave ___________	13b Edge Patching Ext. ________%
6. Raveling _________	11. Sags & Humps ___________	13c Edge Lane < 10’ ____________%
7. Flushing _________	13a. Edge Raveling Ext. ____________%	14. Crack Seal Condition _______%

	2	3	4	5	8	9	13	
Direction								
Fwd								
Rev								
Total L								
Severity M								
Data H								

Name:	From:	To:
1. Rutting & Wear _________	10. Corrugations & Wave ___________	13b Edge Patching Ext. ________%
6. Raveling _________	11. Sags & Humps ___________	13c Edge Lane < 10’ ____________%
7. Flushing _________	13a. Edge Raveling Ext. ____________%	14. Crack Seal Condition _______%

	2	3	4	5	8	9	13	
Direction								
Fwd								
Rev								
Total L								
Severity M								
Data H								
Previous L								
Rating M								
Data H								

COMMENTS:) ____

____

____

____

Appendix G

Examples of Customized Rating Systems

Pierce County Pavement Rating Method

A Summary of the data collection and distress quantity method performed in Pierce County.

HISTORY OF PAVEMENT RATING

Pierce County uses the accepted NWPMA's method for identifying and collecting distress quantities on the Counties Road System. These methods have been modified slightly to conform to the needs of the Counties Maintenance and Repair Program.

Pierce County has been conducting pavement ratings since 1992. Since that time the method of data collection has not changed. In 1992, we tried to determine the worst lane. Rating crews often changed their rating sample to what they thought was the worst lane in the middle of rating a segment. This approach proved to be a waste of field time. In addition, it was determined through analysis of the rating data that those ratings produced inconsistent results. In 1994 it was decided that in order to have some measure of consistency of ratings over time we should rate the same lane in a predetermined direction for the life of that road.

Listed below is description of the different defect categories that are in use for Pierce Counties annual rating Program. These methods are unique to Pierce County and should not be applied to any other agencies road system without considering the effects that these methods might have on the overall rating.

PAVEMENT DEFECT CATEGORIES

Rutting and Wear: The extent of rutting is assumed to represent the entire length of the segment in the wheel path. The severity of rutting is recorded with a Yes in the Low, Medium, or High category. When the data is transferred to the database, the value of rutting is recorded in the LOW severity category only as either a 1=low, 2=med, or 3=high. Disregard any rutting that is localized or less than 100' in length.

Fatigue (Alligator) Cracking: The extent of alligator cracking is measured as a percent of both wheel paths. Choose the predominant severity level of cracking that best represents the entire segment. Since alligator cracking is a percent wheel path measurement, the overall percentage in that segment could be the same even if the actual area covered by alligator cracking is different. *The wheel path covers ½ of the rated lane therefore it doesn't matter if the physical cracking was 1' wide or 5' wide at the same length. In addition, the whole width of the rated lane would be fully cracked if the actual defect extends to cover 2/3 or more of the total width*. Potholes or other occurrences of missing or destroyed pavement and temporary patching are included with alligator cracking.

Longitudinal Fatigue Cracking: *The extent of Longitudinal cracking is measured as a percentage of segment length for the entire area of the rated lane (including the center or paving joint of the road)*. Choose the predominant severity level of cracking that best represents the entire segment. The percent cracking may exceed 100% of the segment length. *There is no distinction between fatigue and non-fatigue related longitudinal cracking. Included is all cracking around utility structures and curb and gutter seems*.

Transverse Cracking: The extent of transverse cracking is measured as counts per unit length. Choose the predominant severity level of cracking that best represents the entire segment. *Transverse cracks must be at least 2' in length to be considered*.

Raveling and (Aging or Weathering): The extent of raveling is estimated and expressed relative to the total area of the rated lane. *Raveling is only collected on ACP surface roads*. Record the appropriate extent by using LOC, WHL, or LAN in the field that best represents the average condition of the segment.

Flushing/Bleeding: The extent of Flushing/Bleeding is estimated and expressed relative to the total area of the rated lane. Record the same as Raveling. Flushing/Bleeding can occur on both ACP and BST surface pavements.

Maintenance Patching:	The extent of skin (chip seal) patch is measured as a percent of both wheel paths. Skin patching is measured the same as alligator cracking. *Any distresses that exist within the limits of the skin patch are also counted and recorded in the appropriate defect category. Grader, full depth, or utility patching is generally considered an improvement to the pavement condition and therefore not included in this defect category.*
Corrugation and Waves:	*Identify only if the condition exists within the rated segment. Record Corrugation and Waves, on the rating form, with a Y or N. When the data is transferred to the database the value for Corrugation and Waves is a 1 in the low severity level if the condition is present.*
Sags and Humps:	Same as Corrugation and Waves. *Sags and Humps are also used to quantify the existence of defects that do not fit the normal categories such as depressions or tree roots.*
Pavement Edge Condition:	The extent of Edge Raveling is measured as a percentage of the segment length. *When edge raveling exists in combination with alligator cracking both defects are counted.* ***Temporary*** *edge patching is included with alligator cracking. Permanent Edge Patching and Edge Lane Less than 10' are not included in this category.*
Crack Seal Condition:	*This distress is collected for inventory purposes only. Identify if cracks in the segment are sealed or not. Y=sealed and N=not sealed. Choose the predominant condition to determine if the segment has crack seal or not. If crack seal exists in the segment and the seal has opened or pulled away from the crack it is not sealed. Treat the underlying cracks below the seal as if there were no seal at all.*

In the future we are looking at making changes to the way we collect our distress data. Examples of which might be rating 100% of the road surface, separating Fatigue and Non-Fatigue Longitudinal cracking, and measuring the actual area of distress.

Spokane County Rating Procedures

Spokane Counties rating procedures follow the Pavement Surface Condition Rating Manual. The only deviation from this standard of rating comes from the actual square footage rating of alligator and patching.

Alligator: **Alligator cracking is rated across the full lane width, predominant severity is recorded in square footage of occurrence. Potholes are recorded as high alligator for the affected area.**

1994-1997: Rated in linear feet, calculated as follows;
((length of alligator-linear ft./ (length of segment*2))*100
Entered into system as a percentage.

1998-1999: Rated in square feet, calculated as follows:
(length * width) = square feet of distress
Entered into system as square footage of distress

Longitudinal: **Measure the total length of all cracking that occurs in traveled lane. The predominant severity is recorded in linear feet. Cracks on the centerline of the road, and cracks not within 6" of the fog line, or acp edge, are counted.**

1994-1997 : Rated in linear feet calculated as follows:
((length of longitudinal cracking in linear ft./length of segment)*100)
Entered into system as a percentage

1998-1999: Rated in linear feet calculated as follows:
(length) = length of distress
Entered into system as linear feet of distress

Transverse: **Actual Counts of transverse cracks existing in the rated lane for the entire segment. The predominant severity is recorded. Transverse cracks are counted if they extend across one wheel path, and are a minimum of 2 feet in length.**

1994-1997: Rated in counts per 100 feet calculated as follows:
((# Of transverse cracks per segment/5)***(assumes rating segment of 500')
Entered into system as cracks per 100 feet

1998-1999: Rated in actual counts per segment.
Entered into system as counts per segment.

Patching: **All patches are rated, maintenance and utility. The determination of the severity level does not correspond to the Rating Manual. The severity level of the patch is actually determined by the condition of the patch rated, not by the type of patch. Patches are recorded in square feet of occurrence.**

1994-1997: Rated in linear feet, calculated as follows;
((length of patch-linear ft./ (length of segment*2))*100
Entered into system as a percentage.

1998-1999: Rated in square feet, calculated as follows:
(length * width) = square feet of distress
Entered into system as square footage of distress

Edge Condition: Measure the predominant severity of distress in linear feet. Severity levels correspond to Standard Rating Procedures.

1994-1997: Rated in linear feet, calculated as follows; ((length of edge condition in linear feet/ length of segment)*100 Entered into system as a percentage.

1998-1999: Rated in linear feet, calculated as follows: length of edge condition in linear feet = length of edge condition in linear feet.
Entered into system as linear feet.

Rutting: Record the predominant severity that best represents existing roadway condition. Extent is considered to be the full length of the segment.

1994-1997: Rated as a 1-2 or 3, for predominant severity**.**

1998-1999: Rated as a .25”, 50” or .75”, for predominant severity.

Raveling/Flushing: Record the predominant severity for the distress,
Identify the extent as localized, wheel path, or entire lane. The extent is considered to be the length of the rated segment.

1994-1997: Rated in length of the distress.
Entered into system as linear feet of distress.

1998-1999: Rated as a 1-2 or 3, for predominant severity.

Index